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MODIFICATIONS
TO
DETAILED DEVELOPMENT PLAN

SUBMITTED BY
ASHLAND OIL, INC., LESSEE
AND
**OCCIDENTAL OIL SHALE INC., OPERATOR
OF THE C-b SHALE OIL VENTURE**

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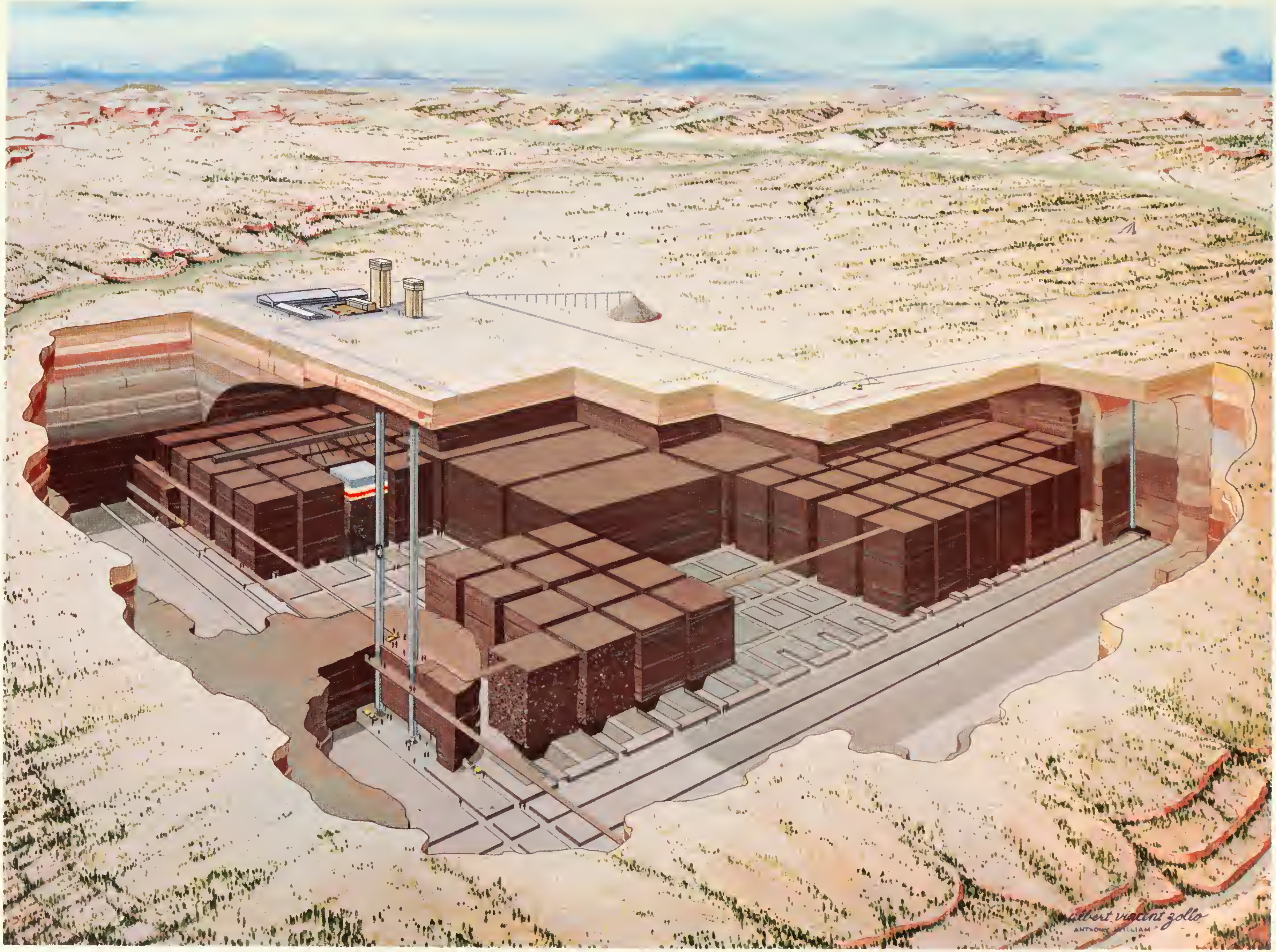
ASHLAND OIL, INC., LESSEE

AND

OCCIDENTAL OIL SHALE INC., OPERATOR
OF THE C-b SHALE OIL VENTURE

PREPARED FOR SUBMITTAL TO THE AREA
OIL SHALE SUPERVISOR PURSUANT TO
LEASE C-20341 ISSUED UNDER THE
FEDERAL PROTOTYPE OIL SHALE
LEASING PROGRAM

FEBRUARY 1977



C-b Oil Shale Venture
Occidental Oil Shale, Inc.
Ashland Oil Inc.
Colorado

The Ralph M. Parsons Company
Engineers/Constructors
Pasadena, California

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I. GENERAL INTRODUCTION AND SUMMARY

A. Introduction

This modification to the Detailed Development Plan is being submitted by the lessee, Ashland Oil, Inc., and Occidental Oil Shale Inc. (OXY), a wholly owned subsidiary of Occidental Petroleum Corporation, successor in interest of Shell Oil Company, lessee, with Ashland Colorado Inc. (Ashland), a wholly owned subsidiary of Ashland Oil, Inc., and OXY developing the tract under a partnership agreement. Ashland Oil, Inc. and Ashland acquired the entire lessee interest in the Tract C-b lease as a result of its withdrawal by the other original lessees. OXY has developed and is obtaining patents on its process for the recovery of oil from the shale utilizing the OXY Modified In Situ Process. In this new joint C-b Shale Oil Venture, Ashland granted OXY a 50% interest in the C-b lease and the Tract C-b in exchange for the right to use the OXY Modified In Situ Process to develop the resource under Tract C-b.

On April 1, 1976, Ashland Oil, Inc. and its former partners paid the third installment of $23,557,600.08 under the terms of the lease. This lease grants..."the exclusive right and privilege to prospect for, mine by underground or surface means and process by retorting or by in situ methods or otherwise, as he may reasonably choose, and in accordance with approved plans...."

On February 9, 1976, the C-b Oil Shale Project submitted its Detailed Development Plan (DDP) to the Area Oil Shale Supervisor (AOSS) for approval in accordance with the terms and conditions of oil shale Lease C-20341.

On November 22, 1976, the AOSS notified the Lessee as follows:

"The Area Oil Shale Office has completed the required review of the Detailed Development Plan which you submitted for Colorado Oil Shale Tract C-b on February 9, 1976 and has found that, with the additions developed during the review process, the plan meets the terms and conditions of the oil shale lease. Its implementation, however, requires resolution of issues which resulted in a 1-year suspension of operations effective September 1, 1976."

The DDP Modification is being submitted to address those areas of change in the Lessee's plan brought about by the use of the OXY process for development of Tract C-b. It is believed

(assuming further geotechnical confirmation work currently being performed yields positive results) that this modification to the plan for development of Tract C-b will resolve the technical problems which were of concern to the lessee in early 1976.

The Lessee has completed the 2-year baseline monitoring program and has submitted eight Quarterly Data Reports, eight Summary Reports, a two-volume Socioeconomic Report, and an Annual Summary and Trends Report to the AOSS.

The Lessee will shortly deliver the ninth Quarterly Data Report and the Second Annual Summary and Trends Report, which is a review and analysis of the 2-year baseline data program.

This DDP Modification, which requests approval to develop the Tract C-b using the Modified In Situ Process, provides a comprehensive statement of the Lessee's revised plan for operations on the tract and will focus on changes from the DDP. It will also identify those areas of the current DDP that will not be changed and will point out those areas no longer applicable.

As with the DDP submitted in February 1976, it is necessary that this modification be approved by the AOSS with consideration of the Lessee's requirement to comply with the due diligence requirements of the lease.

B. OXY's Modified In Situ Experience

The OXY modified in situ process is the result of 4-1/2 years of extensive field-testing to prove the economic and environmental feasibility and the safety of a total system for the in situ recovery of oil from the kerogen in oil shale. The process package covers field-developed know-how, coupled with patented techniques and methods that include the following aspects of the OXY process:

(1) Unique retort designs for optimum recovery of oil from shale, balancing oil yield against compressor requirements, mining costs, water requirements, gas recovery, recycle and treating.

(2) Proprietary retort gas compositions that maximize heat transfer and oil recovery and minimize water usage consistent with resource recovery.

(3) Mine designs that have been field-tested to maximize mining rates, minimize explosives requirements, and which permit simultaneous mining, rubbling, and retorting.

(4) Retort operations that demonstrated methods for:

- Igniting and controlling retorts to obtain maximum resource recovery.
- Controlling retorting temperatures to avoid sintering and plasticization.
- Shutting down retorts.
- Starting retorts using heat and gas from completed retorts for ignition.
- Controlling and correcting retorting to maintain a horizontal combustion front.

(5) Treating of retort product gas to meet environmental regulations.

(6) Control of the retort operation to produce a gas of sufficient Btu content to be usable for process heat, steam, and potentially turbine conversion to electric power.

(7) Safe mine operations during retorting.

(8) Techniques for the revegetation of raw shale rock mined to provide retort voids and adits.

(9) Rubbling techniques designed to yield uniform cross-sectional voids with particle size distributions for in place retorting.

Section II of this DDP Modification is divided into three main subsections as follows:

- Chronological history of the OXY modified in situ field-test program.
- Discussion of key areas researched.
- Discussion related to regulatory experience in certain technical areas.

C. Summary of Federal Prototype Oil Shale Leasing Program

The Federal Prototype Oil Shale Leasing Program is reviewed in Section I.B of the DDP. The reader of this modification is referred to that document for a review of events up to submission of the DDP on February 9, 1976.

Since then, the Lessee of Tract C-b requested on March 2, 1976, and was granted effective September 1, 1976, a suspension of operations pursuant to Section 39 of the Mineral Leasing Act (30 USC 209) and Section 22 of Oil Shale Lease Number C-20341.

On November 2, 1976, Shell Oil Company announced its withdrawal from the C-b Oil Shale Project and on November 3, 1976, Ashland Oil, Inc. announced the formation of a new joint venture with Occidental Oil Shale, Inc. to proceed with development of Tract C-b.

D. Organization and Use of the DDP Modification

The DDP Modification represents an attempt to present information in a direct, specific, understandable, and practical manner that focuses on the changes, yet preserves the applicable parts of DDP. For that reason, there will be many references to the DDP for details on specific aspects of the project that do not depend upon the type of development taking place on Tract C-b.

Section I of the Modification is a General Introduction and Summary. Section II presents OXY's modified in situ oil shale experience. Section III describes the construction and operations of the facilities as they are planned chronologically. Section IV discusses several options and alternates that may be considered later as amendments to the base plan. Environmental control plans outlined in the DDP that require modification are presented in Section V. Changes to the environmental monitoring plans for the revised approach are discussed in Section VI. Socioeconomic considerations are discussed in Section VII.

The numerical data (retort and shaft dimensions, process quantities, etc.) presented are nominal based on preliminary engineering design. These may be adjusted to suit the detailed design composition of all components during final engineering.

E. Summary of Lessee's Commercial Program

1. Summary of Activities

The development of the commercial modified in situ facilities shown on Project Plot Plan, Figure I-A, is represented on the Commercial Development Schedule, Figure I-B. The Tract C-b development program will extend from September 1, 1977, starting with site preparation, to September 1982, when the mine and surface facilities will be capable of full-scale production.

The property will be mined by developing successive geographic areas called panels. A panel will contain several

groups of retorts. These groups are referred to as clusters or retort clusters. A retort, the basic unit, is a column of rubbled shale containing a certain void fraction bounded by undisturbed pillars. It is envisioned that a group or cluster of eight retorts will be processed concurrently. Clusters will be brought on-line in such a sequence that the number of clusters operating at one time within a panel will produce the required quantity of shale oil.

a. Site Preparation and Shaft Sinking

The first site activities starting in September 1977 will be to get shaft sinking underway. Underground development can proceed only after shafts are available.

While the shaft-sinking operations are being mobilized, certain site preparation and preconstruction activities will proceed. These will include preparation or extension of service roads, construction of water storage to receive underground water from initial dewatering operations, and necessary grading for temporary construction facilities, fencing, etc.

The Lessee will construct five vertical mine shafts on the tract. The ventilation/escape shaft (12 feet in diameter), and the temporary gas shaft (6 feet in diameter) will be located as shown in Figure III-A. Three shafts, the production shaft (34 feet in diameter), the service shaft (34 feet in diameter), and the gas shaft (34 feet in diameter), will be located at the site prepared for mine surface facilities as shown in Figure III-B.

Of the four major shafts, the first to be completed will be a 12-foot-diameter shaft 500 feet from the northern property boundary. This shaft will perform a dual service during the development period. First, it will serve as a temporary production shaft until the main 34-foot-diameter production shaft becomes available, and later it will serve as a ventilation/escape shaft for the mine.

b. Ancillary Development

The 12-foot-diameter shaft will be completed first. While the 34-foot-diameter shafts are still being constructed and major mine headings and levels are being opened up, an ancillary facility will be constructed in the vicinity of the 12-foot-diameter shaft. This facility will include two or more commercial-sized retorts, retort clusters and attendant equipment to operate them. This will permit the processing of a thick section of high-grade oil shale, establish the environmental monitoring procedures, obtain operating experience, and provide a site for the training of mine and processing personnel.

Later, as the main shafts and other full-scale plant units become available, this ancillary facility will be incorporated into the full-scale facility.

c. Full-Scale Modified In Situ Plant and Operations

The construction period of the full-scale commercial facility will begin with shaft sinking in September 1977 and end September 1982 when the first cluster within the commercial panel is kindled. From this time on mining will no longer be a preproduction activity as part of the construction program; it will then become a production operation. As more clusters are brought on-line production will increase and full-capacity production (57,000 bbl/day) will be achieved in about 12 months, or by September 1983.

Within the 5-year construction period, the ancillary retort facilities will be developed and processed as described in Section III.D. The ancillary facilities will use the shafts and some increments of the full-scale oil/gas processing units for their operations.

After key development drifts are driven at all levels around the panel, the principal work of retort preparation will begin in May 1981 and continue to September 1982. The construction of the major oil/gas processing units and general facilities will occur between January 1981 and September 1982.

Operations will continue from September 1982 to about the year 2040, when the resource interval will be exhausted.

(1) Description of Mining

The mine will be developed for commercial operation in two basic degrees. The first will include sinking two small shafts of approximately 6 and 12 feet in diameter to prepare an ancillary development of commercial size in situ retorts for operation. This will permit establishing environmental monitoring procedures, obtaining operating experience and providing a site for training of operating personnel. The second will include sinking of three 34-foot-diameter (production, service, and gas) shafts and developing the full-scale mine for commercial operation of in situ retorting.

Multiple levels of access are required for full-scale in situ retort development and operation. The uppermost provides process access and acts as an air plenum for distribution of air supplied to the retorts. Access levels penetrate the retorts below the air level to allow creation of voids required for rubbling. The production level is below the retort and is used

for withdrawal of material removed during development and creation of retort voids. It also allows gathering of the oil and water produced by the retorts in operation.

Immediately below the production level is the gas level, which contains the gas collecting drift through which the gaseous products of combustion are collected and carried to the gas shaft and hence to the surface facilities.

The initial small shafts will be retained and used for ventilation, escape ways and mine dewatering.

The large-diameter production and service shafts will be used for ventilation and to supply air for the retorting process.

Detailed descriptions of mine development plans are included in Section III of this document.

(2) Description of In Situ Retorting

The Modified In Situ Process is a method of retorting oil shale underground as compared to conventional surface retorting in which shale is mined, transported to a centrally located surface plant for retorting, and the spent shale ultimately disposed.

In the Modified In Situ Process, retorts are created by mining out only enough shale to provide a void fraction for rubbling the remaining shale by blasting and to provide permeability for gas flow during operation. These in situ retorts consist of groups or "clusters" of eight 200-ft x 200-ft x 310-ft-high rubble columns or chimneys. Undisturbed pillars function as control partitions between operating retorts.

The processing of a cluster of retorts consists of several steps. First, a retort within a cluster is kindled from the top by externally fueled burners. When the temperature at the top of the retort is sufficient to sustain reaction, the burners are shut off and a regulated mixture of air and steam is drawn into and through the retort by exhaust blowers on the surface. Residual organic material is combusted with the air in the feed gas. The hot combustion gases flow down through the retort and supply heat to the raw unretorted shale below. As the shale is heated, the organic material or kerogen decomposes into oil vapor and other gases that are carried along with the combustion gases while some residual organic material remains in the rubble. Steam in the feed gas acts as a diluent to the oxygen in the air to control the reaction temperature and reacts with some of the residual organic material, forming carbon monoxide and hydrogen to improve the heating value of the product gas. Some of the mineral

carbonates in the shale are also decomposed to carbon dioxide gas and mineral oxides. As the gas mixture flows down through the retort, it preheats the raw shale. At the same time, the oil and some of the water vapor are condensed. Product liquids and gas leave the bottom of the retort and move to the surface for further processing as product oil, produced fuel gas, and water.

As retorting progresses, the combustion and retorting zones move slowly down through the in situ retort. Between 7 and 8 months are required to process a cluster. When retorting is complete, the air and steam feed are stopped and the in situ retort is closed off. The spent shale remains underground with no need for surface disposal.

Surface process facilities consist only of oil/water separation equipment, exhaust blowers, a sulfur removal unit for treatment of product gas, and boilers to produce process steam from fuel values in the product gas.

(3) Water Supply and Disposal

Water requirements for development stages and for full-scale commercial operation are shown in III.E.8, Water Treatment, Use, and Disposal. Water will be available from the primary source, mine dewatering. Commercial operation will require about 2500 gpm. Present information indicates that water supply and requirements will essentially be in balance. Any deficiency will be made up either from on-tract wells or from off-tract sources, as discussed in DDP I.D.6 and III.D.2.

If a surplus of water occurs, the excess will be stored and then either reinjected or treated and released as planned and outlined in DDP II.M.2.

(4) Off-Tract Facilities

As described in the DDP, a staging area and terminal facility will still be required for off-tract facilities. The access-road corridor as outlined in the DDP still applies.

With the expected arrival of Alaskan crude on the West Coast, it is generally thought that the Four Corners area and the Texas-New Mexico crude oil lines will soon be filled with Alaskan crude. The proposed La Sal pipeline described in the DDP would deliver shale oil into this area and on to a southern or a western market.

This DDP Modification presents an additional alternate pipeline route (Section III.E.5.f) which will go generally north and east to tie in with an existing pipeline system which is reported to have 70,000 to 80,000 bbl/day of available

space in Casper or Guernsey, Wyoming. This will allow shale oil to be delivered into the crude oil deficient northern tier and central states

d. Postoperations

Decommissioning of the plant and rehabilitating of the site are discussed in the DDP, and apply in general to this mining and retorting scheme.

The processed shale remaining underground will have been treated according to methods described in Section V of this DDP Modification.

2. Resource Recovery

The shale interval from which oil will be extracted (310 feet) contains about 3.0 billion bbl in place. Of this, 1.2 billion bbls will be recovered by the In Situ Process. The productive life has been calculated at approximately 56 years. This is based on a daily throughput rate of approximately 57,000 bbl/day from the modified in situ facility. If the option is exercised to surface retort the mined out shale, the total recovery would be about 1.65 billion barrels.

Nahcolite and dawsonite are present to a very minor extent in the shale zones, but these latter deposits are so dispersed and represent such low concentrations that it is deemed uneconomic to recover them.

3. Schedule, Manpower and Cost Estimates

a. Schedule

Development, construction, operation, and eventual decommissioning of the proposed commercial oil shale complex are planned to proceed according to the schedule as set forth in Figure I-B. Major facilities associated with the modified DDP project include: shafts and mine; ancillary development; and full-scale in situ mine and process.

In the last quarter of 1977, all activities necessary for major shaft sinking, site development, and final detailed engineering design will commence. The development sequence spans from the start of engineering and procurement (2/1/77) to beyond the starting date of the full-scale commercial in situ facility (9/1/82).

Milestone dates referenced to the Proposed Commercial Schedule, Figure I-B, are as follows:

9/1/77	Start Construction Activities
5/1/80	Start Initial Retorts of Ancillary Facility
9/1/82	Start Operation of Full-Scale In Situ Plant

b. Manpower

Manpower estimates are shown on Figure I-C.

Over a 6-year period from 1977 to 1983 there will be a gradual increase in permanent site personnel to 1,600. After 1983 this number will remain constant. In addition to permanent personnel there are two periods during which temporary construction personnel will be onsite. The two periods are as follows:

	Peak Total Population
Ancillary Development	1,180
In Situ Construction	2,900

In each period the buildup to peak personnel occurs over a period of about 2 years and the drop off in about 1 year.

c. Cost Estimates

Definitive cost estimates for a commercial oil shale project can be made only after further experience has been gained and more information is gathered on site characteristics. Any estimates made at this point are based upon preliminary engineering design and project scheduling. Order-of-magnitude estimates have been made to provide a general projection of the capital and operating costs which are expected to occur during the life of the project. These estimates assume favorable economic and political climates which allow proceeding on the planned schedules. Individual components of costs may vary significantly or may be eliminated in actual practice.

Capital cost estimates prepared for this document show overall project costs through the time of plant construction, but exclude interest during construction and deferred capital expenditures. Project estimates do not include escalation costs. Order-of-magnitude capital estimates for the modified in situ system are shown in Table I-A.

Table I-A - Modified In Situ Estimated Capital Investment

Mine	
Shafts, Hoist, and Appurtenances	$ 38,053,000
Mobilization	9,537,000
Equipment and Spares	21,450,000
Conveyors and Materials Handling	19,003,000
Labor	18,360,000
Other Materials	29,328,000
Taxes	965,000
Subtotal	$136,696,000
Oil and Gas Processing	
Steam Generation Plant	$ 21,060,000
Water Treatment Plant	36,250,000
Gas Treatment Plant and Heater-Treater	10,200,000
Other Major Equipment	15,568,000
Other Materials	12,405,000
Taxes, Spare Parts and Miscellaneous	3,036,000
Field Indirects	4,519,000
Subtotal	$103,038,000
General Facilities	
Emergency Generating Equipment, Package Boiler, Hoist, Cranes, Air Compressors, Storage Tanks, and Miscellaneous Equipment	$ 9,532,000
Direct Materials, Concrete, Electrical Insulation, Roads, and Other Civil Work	61,088,000
Other Direct Costs, Spare Parts, Taxes, etc.,	2,984,000
Field Indirects	10,378,000
Subtotal	83,982,000
Total Installed Equipment	$323,716,000
Contractors Engineering, Home Office, Fees, Working Capital and Contingency	
Subtotal	$118,893,000
TOTAL CAPITAL INVESTMENT	$442,609,000

4. Options and Alternatives

Several options may present economically attractive alternatives as a supplement to the basic program described in this DDP Modification. The principal options envisioned at this time are:

- Surface Retorting of Mined-Out-Shale
- On-Site Electric Power Generation from Low-Btu Product Gas
- Alternative Water Supply and Management

Each of these cases is highly dependent upon economic and technical factors that cannot be determined at this time. However, considering the length of the program, it is conceivable that many of these factors will become definable, resulting in an alternate course that will be advantageous to the program.

These options are discussed in Section IV of this document.

5. Plans and Procedures for Environmental Protection

The OXY Modified In Situ Process will be used to extract oil from oil shale. This change in methods is reflected in some of the environmental control plans.

The discussion in Section V focuses on aspects in which the control plans for the revised approach differ from the plans in the DDP. The elements of the control plans in the two cases are the same. Thus, for ease in comparing the two cases, the subsections are by subject and in the same order as in the DDP.

The environmental protection plans described in the DDP are generally applicable to the revised program. The introduction of in situ retorting requires additional plans for protecting subsurface waters from pollution and for preventing fires underground. Subsurface water pollution that might occur can be prevented; see Section V.B for details. Fires are prevented by the low permeability and high heat capacity of the rock, by operating the retort system at negative pressures relative to ambient conditions, and by controlling the air supply to each retort. See Section V.E for details. The environmental control and monitoring procedures will be tailored to protect the environment from significant adverse changes.

See Table I-B for estimated area of disturbed surfaces through year 2005.

Table I-B - Estimated Surface Disturbance by Year Overall (Acres)

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11 to Year 2005	Total by Activity
Mine Development												
Surface Facilities 12-ft shaft		8										8
Steam Generation		3										3
Gas Treatment		3										3
Cottonwood Gulch												
Mined Rock Fill Area		15	20	75	100	100						310
Impound Pond			4									4
Road Construction												
Tract Access		8	20	25								53
Service		3	5									8
In Situ Gas Treatment Facilities			44	30								74
Mine Production and Service Shaft Area			15	15								30
Sorghum Gulch												
Dam Site			3									3
Reservoir			3	17								20
Shale Storage Area							100	100	100	100	540	940
Total by Year (Accuracy of Estimate ±25%)		40	114	162	100	100	100	100	100	100	540	1,456

6. Due Diligence

The schedule presented in this DDP Modification shows production commencing in 1980 from an ancillary facility. This is considerably earlier than outlined in the DDP and allows the Lessee to meet the due diligence requirement of Section 10(a)(3) of the lease.

The time schedule for development of the lease is believed to be attainable assuming no unforseen delays. The schedule is based on restarting shaft-sinking and dewatering in September 1977 when the suspension of operations ends, subject to approval by the AOSS of the Modified DDP plan prior to September 1977 and securing all required permits.

Major uncertainities still exist, and the potential for delays is ever-present. The likelihood of reducing the schedule is remote and the possibility of it being extended is high.

II. OXY'S MODIFIED IN SITU BACKGROUND

A. Introduction

This modified detailed development plan is based on 4-1/2 years of extensive field testing of the OXY Modified In Situ Process. The purpose of this section is to provide as much of the background information as possible so that the following design sections can be understood, and so that the state of development can be appreciated.

This section is presented in three main subsections: a chronological history of the OXY modified in situ field test program, a discussion of key areas researched, and a discussion related to regulatory experience in certain technical areas.

B. Chronological History

The OXY process was conceived in the late 1960s at OXY's research laboratory in LaVerne, California. Initially, engineering evaluations and limited laboratory work were undertaken. Later, a major effort in land acquisition began. After approximately 4 years of searching, in June 1972 OXY signed a 3-year lease-option on properties owned by D.A. Shale, Inc., The Callahan Trust, and several private individuals. This so-called D.A. Shale property consists of approximately 4,000 acres on the south edge of the Piceance Basin, 25 miles south of the C-b property. Approximately half, or 2,000 acres, are underlain by oil shale very similar in nature, but lower in grade and thickness, to that on the C-b property.

Site access work began in July 1972, after receipt of a BLM special land use permit, and mining commenced in early September 1972.

The original field test program consisted of mining and retorting three in situ retorts, each approximately 1,000 square feet in cross-sectional area and varying in height from 72 to 114 feet. While these are small in comparison to the envisioned commercial retorts, they were large enough to test basic concepts and to permit scale-up to full size at a later date. They were also

large by any normal process development standards. For example, the smallest retort contained over 25 times the ore used in the largest Bureau of Mines aboveground retort at Laramie, Wyoming. These three in situ tests utilized two basic rubbling concepts, described below.

The first mine opened, known as the Experimental Mine, consisted of a single adit 8 by 8 feet and approximately 1,400 feet long with individual crosscuts to each of the three retorts. Retort 1E was prepared in winter and spring of 1972 and 1973, and retorting startup was attempted in May 1973. Various problems associated with ignition, temperature and pressure measurements and control, sealing of the retort and other mechanical-type start-up problems delayed actual retorting until July 1973. In spite of these problems, Retort 1E was operated satisfactorily and, upon completion in late September 1973, had produced over 1,200 barrels of oil.

Retort 2E was prepared in 1973 and early 1974, and retorted in 1974. This retort utilized the same basic rubbling design as in 1E but with several changes. Changes were a reduced void volume, a significant change in the blast pattern itself, and an increase in the retort height by 20 feet. Various other non-critical improvements were made on the basis of the Retort 1E experience. Retort 2E presented a new set of technical challenges both in fragmentation and in retorting. The 20 feet of additional retort height consisted of oil shale that was considerably lower in grade than that normally retorted. Retort 2E produced a yield of 1,400 barrels of oil.

While Retort 2E was in preparation, road construction started for a new mining operation about two-thirds of a mile away. This mine was designed with two purposes: (1) to test at least one full-size in situ retort, and (2) to provide a full-size developmental mine that could be converted into commercial operation without opening new adits and new permanent facilities. In essence, this mine utilized the first commercial mine design for an in situ operation. The C-b design incorporates many features of this original design.

Retort 3E, the final retort in the Experimental Mine, utilized an entirely different rubbling scheme with two sublevels above the retort floor. These were mined from a short raise alongside the retort. At the same time, another raise and an incline were added to the mine to provide improved mine ventilation, safety, and access to new working areas. Retort 3E was also about 20 feet taller than Retort 2E and, again, the added height was in low-grade oil shale. Because of the different fragmentation system, it had significantly different operating characteristics than Retorts 1E and 2E. While new problems were encountered with Retort 3E, its operation was much improved over the previous retorts because many of the problems uncovered during development

and processing of those retorts were solved. Retort 3E produced 1,600 barrels of shale oil, bringing the total production from the three retorts to over 4,000 barrels.

Retort 4, the first full-size retort in the commercial mine area, was originally designed on the basis of the Retort 1E test; however, this design was later altered significantly to test a third fragmentation system. The retort was mined in the first half of 1975 and rubbled August 10, 1975. It was ignited after extensive flow and tracer testing in December 1975. Retort 4 measured 120 by 120 feet by 270 feet in height and included, for the first time, the B-groove, a thick zone of barren rock within the rubble. In total volume, Retort 4 was 50 times that of Retort 1E and 32 times 3E. Because the B-groove was included, the ratio of oil in place between the retorts was significantly smaller than the rubble tonnages would indicate.

It should be noted that Retort 4, as well as Retorts 1E, 2E, and 3E, contained oil shale of grades varying from 0 to 70 gallons/ton (gpt). The richest section of these retorts was the Mahogany zone defined here as the interval between the A- and B-grooves. This interval contains a section of about 85 feet averaging 24.5 gpt. Within this is a narrower section of 50 feet averaging 30 gpt and, within that section, an even thinner section of 32 feet averaging 35 gpt. The retorting in these richer sections is comparable to retorting on the C-b site. The pressure drop-void volume relationships developed are particularly significant for this development.

The scale-up to the commercial size retorts resulted in additional technological experience and know-how. In spite of the improved rubbling concept, poor fragmentation of a significant part of the oil shale occurred, primarily because of geologic conditions, which did not affect the smaller tests. Even so, Retort 4 gave valuable experience in the ignition of a large cross-sectional area and maintenance of a uniform retorting front over the same area. Approximately 30,000 barrels of shale oil were produced between January and June 1976.

Concurrent with Retort 4 development, a test program on rock fragmentation was initiated. Between 50 and 100 separate test shots were made to ascertain relationships between explosive and geologic variables and rock fragmentation. Much of the data from these experiments were used in the design of Retort 5.

Retort 5 was mined between November 1975 and April 1976. Rubbling followed an extension of the fragmentation test program described above and took place on December 16, 1976. Flow testing and tracer studies are scheduled for February and March 1977, with actual retorting to commence in April 1977. Retort 5 was built using the experience gained from the previous retorts and contained significant design improvements.

Retort 6, representing an extension of Retort 3E, is now under preparation, and will be retorted in 1978.

Concurrent with the major events described, a number of other mining test programs have been carried out. These include a multimonth mine production run aimed at generating meaningful mining cost data to compare with engineering estimates, seismic and air blast measurements, roof support studies, and the reentry into one burned out retort for the examination of pillar retorting, roof conditions and rubbling.

Engineering studies for commercial operations have been carried out in parallel with the field test program; first by OXY in-house personnel and consultants and later by The Ralph M. Parsons Company. Parsons has been working with OXY on engineering since making an initial feasibility study in 1973. Preliminary engineering plans have been prepared for the D.A. Shale property and the C-b property.

C. Research and Development Areas

Additional areas of research during the past 2 years are broken down into the following categories: general mining, rubbling, hydrology, and retorting.

1. General Mining

The decision to utilize a full-scale mining operation in the preparation of Retort 4 resulted in the gaining of much valuable experience in the general area of oil shale mining. This also allowed for the development of mine productivity costs, measurement of equipment reliability, testing of different makes of mining equipment, and extensive experience with maintenance of mining equipment. Experience has been gained in mining tunnels varying in size from 8 by 8 feet to 24 by 24 feet. The use of the large tunnels on the D.A. Shale property has provided valuable experience that is directly applicable to the C-b site. For instance, two makes of large-scale underground drilling jumbos are presently under test; two makes of 8- to 10-yard front-end loaders are being tested; and large-size scaling equipment has been developed and tested.

The Commercial Mine area is a two-level mine with both single- and dual-entry sections. Experience has been gained in ventilation of large areas, multiple headings, the use of large stoppings, and negative pressure ventilation systems.

The selection of the lower level of the Commercial Mine area was such that the rock support properties were much poorer than normally occur in oil shale mines. This necessitated extensive testing of roof bolts and other support systems, resulting in development of an effective support system for use when required.

While geologic effects in the Experimental Mine proved to be of minor consequence, in the large-scale mine they are more significant. As a result, experience has been gained under large-scale mine conditions in the selection of mining horizons and in the handling of other local geologic conditions that affect oil shale mining.

In addition, experience has been gained in dust suppression and in the evaluation of potential mining hazards.

2. Rubbling

One basic requirement for the success of the OXY Modified In Situ Process is the effective rubbling of the oil shale so that it may be efficiently retorted. Key aspects are: fragmentation and void volume distribution control and the evaluation of the results; items specifically related to the rubbling using large amounts of explosive in individual full-size retorts; ground support considerations; and the resultant structural condition relating to gas containment during retorting.

In order to develop a system in which consistent fragmentation occurs within the rock mass and the mined void volume is evenly distributed throughout the resulting rubble pile, the following areas have been investigated in depth in the field test program:

(1) Explosive parameters, comparison of explosives and detonation systems.

(2) Effects of geology on fragmentation.

(3) Explosive patterns: spacing, hole size, timing, etc. (both small- and large-scale).

(4) Mined void volume geometry.

(5) Retort orientation with respect to geologic conditions.

(6) Effect of retort size.

The key to determining the success of rubbling lies in the ability to evaluate the results obtained. Approaches used and pursued in the development program include the following:

(1) Visual inspections.

(2) Drilling within the rubble.

(3) Flow tests and pressure tests.

(4) Tracer tests.

(5) Correlation to theoretical predictions.

(6) Mining after retorting.

(7) Retorting measurements.

(8) Remote measurements.

All of these techniques have been proven valuable; in fact, it is the combination of a number of methods that provides the most accurate evaluation.

A complete new technology had to be developed in relation to the rubbling "event". While the first blast in Retort 1E contained only slightly more than 2 tons of explosives, the large-scale retorts have been detonated with 50 to 85 tons of explosives. Among the technological factors included were the following:

(1) Evaluation and measurement of close-in seismic effects.

(2) Measurement of seismic effects at distances up to 20 miles away.

(3) Measurement and control of air blasts.

(4) Protection of sensitive equipment and nearby facilities.

(5) Protection of bulkheads on existing adjacent operating retorts.

(6) Noise measurements.

(7) Reentry.

(8) Bulking full.

(9) Scale-up from smaller operations.

(10) Use of ammonium nitrate fuel-oil (ANFO) explosive in wet holes.

(11) Up-hole loading systems.

(12) Protection of surrounding pillars and exposed backs (roof).

(13) Hydrologic affects.

Another area related to rubbling is that of support considerations; i.e., the protection of the retort walls and sealing of the retort from the adjacent mining areas. Work in the area of support consists of evaluation of the blast effects and the shift in overburden stress due to rubbling by utilizing rock mechanics technology and finite element analyses. The objectives of these analyses are the determination of pillar and room wall thicknesses required, bulking full requirements, determination of the support given by spent shale to retort walls and back, and the evaluation of thermal effects on the retort walls and back during retorting. In addition, thermal effects were studied by detailed evaluation of mineralogical changes in the oil shale as a result of retorting.

The final key area in rubbling is that of gas containment. The retorts developed must be sufficiently gas tight so that under operating conditions gas in the retort is contained and exits only through the design exit portals and/or pipelines. In pursuing adequate gas containment, evaluation of the following areas has been carried out:

(1) Prevention of pillar cracking, opening of joints, etc., during rubbling.

(2) Bulkhead designs.

(3) Sealing of bulkheads to the oil shale formation.

(4) Sealing formation leaks.

(5) Pressure balances.

(6) Effect of local geologic features.

(7) Maintenance of all pillars and walls used for seals during the retorting.

(8) Evaluation of thermal cracking potential and prevention of leaks resulting from thermal cracking.

(9) Maintenance of boundary pillar integrity during mining and prior to rubbling.

3. Hydrology

Hydrology is considered in other areas of this DDP. The background work to develop the OXY modified in situ technology on the C-b property includes: evaluation of the geologic control on water flow from all information and experience gained on the D.A. Shale property, methods of isolating water from operating and spent retorts, the effect of rubbling on hydrology, the leaching of spent retorts, and the sealing from and/or diversion of water around a retort area.

4. Retorting

Retorting considerations can be divided into three major categories: ignition and startup systems, retorting measurement and control, and downstream operations.

Ignition or startup of underground retorts is a technology considerably different from the same function for aboveground and has required new variations in burner design. A number of different down-hole burners have been investigated and field-tested with good results. The in situ heating requirements are likewise different from aboveground since larger areas must be ignited. Investigation has been made of multiple ignition points as well as the area that can be covered from a single injection source. In addition, reignition after oxygen has been cut off from the retort for a period of time has been thoroughly investigated.

The development of a new type of technology for retorting and the measurement and control of underground retorts has resulted, by necessity, from the in situ nature of this process. Among the areas investigated were:

(1) Conventional temperature, pressure, and flow-measuring devices and variations of the same.

(2) Use of indirect measuring systems to locate flame front and other pertinent retorting conditions.

(3) Drilling within rubbled retorts and making in-rubble process measurements.

(4) Development of a mathematical model to project in-rubble conditions to diagnose external measurements and analysis and to correlate with actual in-rubble measurements.

(5) Material balances around retorts for accurate oil, water, and gas yield data.

(6) Variations in retort gas compositions.

(7) Effect of oil shale grade variations.

(8) Correction of nonideal flow occurrences and other undesired retort operations.

(9) Retorting of surrounding pillars.

In the area of downstream operations, work has been undertaken in the fields of:

(1) Oil and water separation.

(2) Oil clean up, aerosol measurement and elimination.

(3) Power generation from offgas.

(4) Other gas disposal systems.

(5) Corrosion.

(6) Oil handling.

5. Regulatory Experience

During the 4-1/2 years of field tests, OXY has obtained more than 80 permits of various kinds from county, state, and federal regulatory bodies. Many have been of a routine nature, while others have necessitated significant efforts in preparation, in obtaining approvals in a timely fashion and in meeting the permit requirements.

It is not the purpose of this section to document all of the permits obtained or the steps required to obtain review and approval. Rather, a few specific permits and appropriate experiences are described since they are directly related to safety and environmentally sound operation. These permits obtained relate to the use of underground fires within retorts, air emissions, water emissions, and disposal of mined raw oil shale.

The use of open flame or fires underground is normally not allowed, primarily because of experience in coal mining operations. The use of a fire underground for in situ oil shale operations is, of course, essential to provide the heat and good energy balance required for economical shale oil production. The difference between this operation and other mining operations is that the fires and resultant flue gases are totally confined. Operation with these contained fires within retorts requires the issuance of a variance from the Colorado Division of Mines with review and approval from MESA. Thus, two independent reviews occur and one variance is issued. The variance contains conditions deemed adequate by both agencies for the containment of the fires within the

retorts and the resultant gases within subsequent piping or tunnels as well as requirements to continually monitor the system to give an immediate alarm should a failure in the system occur.

In the course of reviewing OXY's variance applications, both Colorado Division of Mines and MESA personnel reviewed the detailed mine layout, retort location relative to working areas, bulkhead and other designs related to gas containment, availability of alternative escape routes in case of failure of any part of the system, mine ventilation, dilution effect resulting from gas leakage into ventilated areas, overall pressure balances between the retort and the mining areas, various monitoring systems to detect leakage, and emergency plans. Two variances resulted, one for the Experimental Mine and, later, one for Retorts 4, 5, and 6 in the Commercial Mine. These variances, which were issued, contain detailed requirements for the facilities design and installation, for monitoring and maintenance of adequate records, and for personnel training. The operations are carefully inspected by both agencies before, during, and after retorting. To date, all variance conditions have been met and no hazardous conditions have resulted. It should be noted that the hazard identified does not relate to the spreading of a fire outside a retort into the general mine area, but rather to the potential diffusion of noxious process gases in the mine.

Permits in the air emission area for retort operation are obtained primarily from the Colorado Department of Health and have included permits to construct, permits to operate, and Air Contaminant Emissions Notices (ACEN). To obtain these permits, complete design and operation of the emissions-related process equipment were supplied to the agency along with projections of actual emissions, monitoring plans, and evaluation of the diffusion of the emissions into the normal air currents. Baseline data were required and have been obtained over a 1-year period for background air quality.

Accurate methods for monitoring of retort exhaust gas composition were first developed using gas chromatography and wet chemical methods and later the addition of a mass spectrometer for identifying minor constituents. Effluent gas is routinely analyzed on a frequent basis and data submitted to the state quarterly on specific components.

Based on the experience gained in the Experimental Mine, application was made for operation of the retorting equipment in the Commercial Mine. Prior to this time, a 100-foot meteorological tower had been installed downwind from the exhaust stack at the Experimental Mine. Air quality measurements had been made both during the time that no retorting was occurring and while Retort 3E was in operation. Mathematical modeling of the mixing of Retort 4 emissions with the atmosphere was undertaken to determine the stack height required to prevent ground level concentrations of specific

components from exceeding standards. Based on analysis of the facilities involved, the adequacy of the emissions monitoring, and the satisfaction that the mixing of these emissions would not result in standards being violated, the state has issued the necessary permits for operations. Quarterly reports of emissions are routinely provided to the state and no violations have been detected.

Water discharges from the OXY process on the D.A. Shale property are of a minor nature, and a permit to spray-evaporate the small amount of excess water on the mine dump has been obtained. Water will be drained from the retorts and used in the mining and process operations. A series of observation wells tapping the shallow aquifers have been drilled in areas near the mining operation, and they are monitored to detect any changes in quality. There have been no changes to date.

Operations on the D.A. Shale site include the disposal of mined raw shale. Experience has been gained in rock dump stabilization.

With the opening of the Commercial Mine area in 1973, application was initially made to Garfield County for a Special Use Permit to dispose of 500,000 yards of mined oil shale. This permit was later amended to allow up to 8 million yards. OXY's permit application was reviewed by the following agencies before being approved and issued by Garfield County:

- Bureau of Land Management (BLM)
- Colorado Land Use Commission
- Colorado Division of Wildlife
- Colorado Geologic Survey
- Colorado Division of Water Resources
- Colorado Division of Mines
- Colorado Soil Conservation Board
- Colorado Land Reclamation Board
- Colorado Department of Health
- Colorado State Department of Highways
- Colorado Division of Planning

Mining of the Commercial Mine area began on a large scale in 1974 and to date approximately 391,000 yards of mined low-grade oil shale have been dumped.

III. COMMERCIAL MODIFIED IN SITU PROGRAM

A. Summary of Activities

The development of the commercial modified in situ facilities is represented on the Commercial Development Schedule, Figure I-B. The Tract C-b development program will extend from September 1, 1977, starting with site preparation, to September 1982, when the mine and surface facilities will be capable of full-scale production.

The property will be mined by developing successive geographic areas called panels. A panel will contain several groups of retorts. These groups are referred to as clusters or retort clusters. A retort, the basic unit, is a column of rubbled shale containing a certain void fraction bounded by undisturbed pillars. It is envisioned that a group or cluster of eight retorts will be processed concurrently. Clusters will be brought on-line in such a sequence that the number of clusters operating at one time within a panel will produce the required quantity of shale oil.

Planning activities will begin in January 1977 with the preparation of specifications and engineering data required for shaft sinking so that contracts can be let within sufficient time to procure the equipment necessary to start sinking shafts on September 1, 1977.

Site preparation and preconstruction will also begin in September 1977 and continue while shaft sinking mobilization is underway.

Of the four major shafts, the first to be completed will be a 12-foot-diameter shaft 500 feet from the northern property boundary. This shaft will perform a dual service during the development period. First, it will serve as a temporary production shaft until the main 34-foot-diameter production shaft becomes available, and later it will serve as a ventilation/escape shaft for the mine.

While major mine headings and levels are being opened up, an ancillary facility will be constructed in the vicinity of the 12-foot-diameter shaft. This facility will include two or more retorts and the attendant equipment to permit the processing of a thick high grade oil shale section to establish the environmental monitoring procedures, to obtain operating experience

for processing a cluster of retorts, and to provide a site for the training of mine and processing personnel. Later this ancillary facility will be incorporated into the full-scale facility systems.

The construction of the ancillary facility will begin in April of 1979. The first retorts will be prepared and ready for processing by May of 1980. During this period the main development and construction of the mine, the oil/gas processing and general facilities on the surface, and development of additional retort clusters will continue.

By September 1982 the first eight-retort clusters in the initial panel will be kindled. Over the next 12 months additional clusters will be brought online until full design production capacity is reached. From then on spent clusters will be retired and fresh clusters will be prepared and processed to maintain design production for the life of the property.

B. Schedule and Manpower

The Commercial Development Schedule, Figure I-B, and the Project Manpower Estimate, Figure I-C, represent the major activities and total personnel on site with time. Chronologically, the major activities and levels of site personnel are as follows:

	Period	Personnel Range
Site preparation and Shaft Sinking	9/77 - 7/79	0 - 900
Ancillary Facilities	5/79 - 7/81	700 - 1,900
Full-Scale Facility Construction	1/81 - 9/82	1,400 - 2,900
Full-Scale Facility Operations	9/82 - on	1,600

The number of personnel onsite will increase steadily to 2,900 by March 1982, except for the period November 1979 to May 1980, when it will decline from 1,180 to 940. Of the 2,900 peak personnel, about 1,600 will be temporary construction personnel, the remainder will be mining and operating personnel.

The number of construction personnel will drop rapidly from March 1982 to March 1983, and the permanent personnel will continue to increase during this same period, becoming constant at 1,600 for the following years.

C. Site Preparation and Shaft Sinking

1. Introduction

The first site activities starting in September 1977 will be to get shaft sinking underway. Underground development can proceed only after shafts are available.

2. Engineering and Design

Because of the requirements of the proposed schedule, and in order to start shaft sinking by September 1, 1977, some engineering design and procurement relating to these shafts will start in February of 1977. This will involve the design, specification, and contractual negotiations for the shafts and shaft contractors. Procurement of shaft-sinking equipment will proceed as soon thereafter as possible. Funds must be committed by April 1, 1977 to start shaft mobilization by September 1, 1977.

It is planned that definitive engineering for the overall commercial program will start approximately in October 1977 and continue through September 1978.

Final mechanical design of each stage of the commercial development will be completed prior to the construction. This is shown on the Commercial Development Schedule, Figure I-B.

3. Site Preparation and Preconstruction

While the shaft-sinking operations are being mobilized, certain site preparation and preconstruction activities will proceed. These will include preparation or extension of service roads, construction of water storage to receive underground water from initial dewatering operations, necessary grading for temporary construction facilities, fencing, etc.

4. Shafts

The Lessee will construct five vertical mine shafts on the tract. The ventilation/escape shaft (12 feet in diameter), and the temporary gas shaft (6 feet in diameter) will be located as shown in Figure III-A. Three shafts [the production shaft (34 feet in diameter), the service shaft (34 feet in diameter), and the gas shaft (34 feet in diameter)] will be located at the site prepared for mine surface facilities as shown in Figure III-B.

The four main shafts will be sunk by conventional methods, and will be concrete-lined. The lining thickness will be determined during the detailed design. The shafts may be sealed where necessary to control disturbances and seepage. Any shaft water inflow will be collected in sumps for transfer to the surface through the mine dewatering system.

a. Coring and Dewatering

In order to properly evaluate underground conditions, the Lessee has developed a program to acquire as much information as possible concerning rock and ground conditions and to obtain more hydrology data before commencing shaft-sinking operations. The program includes drilling of large cores to obtain additional data on fractures, mechanical properties, mineralogy, water quantity and quality in the various aquifers and measurements of permeability and porosity.

b. 12-Foot-Diameter Ventilation/Escape Shaft

The preliminary design for mine access during the early stages of the ancillary facility is based on developing two shafts approximately 1,450 feet apart adjacent to the northern boundary of the tract. One of these shafts is the ventilation/escape shaft (12 feet in diameter), the other is the temporary gas shaft (6 feet in diameter).

The ventilation/escape shaft will be sunk approximately 1,740 feet to the production level. At first, the ventilation/escape shaft will be divided for ventilation purposes and used as a temporary ore production and as a service shaft for men and materials. Subsequently, this shaft will serve as an escapeway and will also provide a source of additional fresh air. It is planned to have the main mine water pumping facilities on the production level near this shaft, as this point will be at the lowest elevation in the mine because of a dip in the formation level. While serving as a production shaft, this shaft will be equipped with a headframe, double-drum hoist, and a ladderway with landings. Hoisting will be balanced by using a cage for men and materials with a rock skip underslung below the cage on each rope. Alternatively, one rope may hoist a rock skip while the other may have a smaller rock skip underslung from a cage. In later phases the rock skips will be removed. This shaft will then only be used for ventilation purposes and as an emergency exit from the mine.

c. Temporary 6-Foot-Diameter Gas Shaft

The temporary 6-foot diameter gas shaft will be sunk approximately 1,700 feet to the production level. This shaft will serve as an upcast ventilation shaft during the development interval until the initial two retorts are kindled. While this retorting is being performed, this shaft will serve as the gas shaft for the first two retorts. When this stage is completed, the shaft will only be used to supplement the mine ventilation requirements.

This shaft will be lined with casing and grout. The shaft linings will be continuous, except for station openings. The thickness of the casing will be determined as part of detailed shaft design.

It may be possible to drive from the 12-foot-diameter shaft to the underground location of the second shaft, and upream a pilot hole to pull a 6-foot-diameter raise. A decision will be possible only after detailed design studies.

d. 34-Foot-Diameter Production Shaft (See Figure III-A.)

The 34-foot-diameter production shaft will also serve as the main ventilation exhaust shaft. It will be sunk approximately 2,100 feet deep to a point about 250 feet below the production level. The present concept is to have a tower-mounted friction hoist that raises balanced skips of approximately 60-ton capacity each. The preliminary design is based on wire rope skip guides, except in the loading and dumping zones where steel guides will be used. The hoist tower will be arranged with a dumping bin feeding a belt conveyor to transport the muck to the disposal area. Below the production level, there will be provisions for the measuring pockets, skip-loading facilities, tail rope loops, spill pocket, and a sump with a pump station. The shaft will be connected to all levels for purposes of ventilation. Under normal mine operations, there will not be any service use made of these shaft stations.

e. 34-Foot-Diameter Service Shaft (See Figure III-A.)

This shaft will serve as an intake for both process and ventilation air. It will be smooth concrete-lined and sunk approximately 1,900 feet to the production level. At the bottom of the shaft, there will be a sump with a pump station. The present concept is to have a tower-mounted friction hoist raising a single double-decked cage sized 26 by 15 feet. The cage will have provisions for loading and unloading through both

ends, and the upper deck will be hinged to permit the loading of unusually long items required underground. The cage will be counterbalanced with a variable system so that weights can be added when handling heavy items of equipment. Rope guides will be used for both the cage and the counterweight. A ladder escapeway with landings will be installed together with service lines for water, electric power, etc.

f. 34-Foot-Diameter Product Gas Shaft (See Figure III-A.)

The gas shaft will be sunk approximately 1,850 feet to the gas level elevation. There will only be one level off this shaft; no connections will be made to any of the development levels. After the gas level is fully developed for servicing the first panel, all fittings will be removed from the shaft. The shaft will be smooth-lined.

g. Shaft Pillars

The pillars for the 12-foot-diameter and the 6-foot-diameter shafts will be 500 feet in radius. The centerlines of these two shafts will be 500 feet from the northern property boundary. The pillar radius for the 34-foot-diameter production and service shafts initially will be equal to the approximate depth from the surface to the level at the top of the retorts. Measured from the shaft centerline this will provide a 1:1 slope or a draw angle of 45 degrees.

It is anticipated that this pillar radius can be reduced when definitive information is acquired as the retorts are expanded over a large enough area to permit determination of the draw angle. The retorts will not encroach upon these pillars until information is developed to establish the actual draw angle for this property.

D. Ancillary Facilities

1. General

The 12-foot-diameter shaft will be completed first. While the 34-foot-diameter shafts are still being constructed and major mine headings and levels are being opened up, an ancillary facility will be constructed in the vicinity of the 12-foot-diameter shaft. This facility will include two or more retorts and attendant equipment to operate them and will: permit the processing of a thick section of high-grade oil shale;

establish the environmental monitoring procedures; obtain operating experience for processing a cluster of retorts; and provide a site for the training of mine and processing personnel.

Later, as the main shafts and other full-scale plant units become available, this ancillary facility will be incorporated into the full-scale facility systems.

2. Surface Facilities

The ancillary surface facilities will be located at three sites (reference Figure III-A). General mine facilities for the ancillary operations will be located immediately adjacent to, and generally south of, the 12-foot-diameter shaft; gas treatment facilities will be just south of the 6-foot-diameter gas shaft; and steam generation facilities will be located in the general area of the commercial mine production and service shafts. A total of 14 acres will be required for these sites.

The general facilities site, located on the second ridge west of Cottonwood Gulch near the north property line, will require approximately 8 acres for the following facilities:

(1) 12-foot-diameter shaft, headframe, and hoist house.

(2) Material bin and truck loading station at shaft.

(3) Electrical power generators, switchgear, and substation.

(4) Office and mine dry trailers and maintenance area.

(5) Fuel oil and product oil storage.

(6) Mine waste treatment and storage.

(7) Water filtration and storage.

(8) Equipment and materials storage and parking area.

The gas treatment facilities, located on the first ridge west of Cottonwood Gulch near the north property line, will require approximately 3 acres for the gas blowers, the Stretford or equivalent gas treatment unit, and a thermal oxidizer and stack.

Steam generation facilities will be located about 4,000 feet south of the 12-foot-diameter shaft. Approximately 3 acres will be required for this site.

An oil-fired steamboiler is planned to be the initial source of steam for the first two retorts and for miscellaneous utility heating. It will be used later for heating and general utility requirements. Feedwater treatment facilities will be located near the steamboiler. The water derived from underground dewatering will be clarified-filtered near the 12-foot-diameter shaft prior to treatment.

Since these surface facilities are to be temporary, and the ridge areas are relatively flat, very little disturbance of the land will be required. Any required leveling of the sites can be accomplished with material excavated during shaft construction or by balanced cut and fill to minimize surface soil disturbance. Facilities for this initial installation will be either mobile or easily removable at the completion of this stage of development. When no longer needed, this area will be revegetated in accordance with specific plans outlined in Section V.K. of the DDP.

The ancillary surface facilities will be expanded during the processing of initial retorts in order to process the first retort clusters, as shown on Figure III-B, and will cover approximately 59 acres. By this time the 34-foot shafts will be completed and these facilities will be connected into the first modules of the full-scale facilities.

The additional areas to be developed include the main production and service shaft site, main gas shaft, gas treatment plant, and steam generation plant sites, mined-shale fill conveyor system, and initial Sorghum Gulch water impoundment area.

The main production and service shaft site will contain the 34-foot-diameter production shaft, 34-foot-diameter service shaft, headframes and hoist houses for the shafts, and mined-shale fill conveyor feeding system.

The initial steam generation and water treatment facilities will be retained in their original locations and used for heating and utility requirements. Water filtration facilities located at the 12-foot-diameter development shaft will be retained and expanded as necessary.

The main gas treatment and steam generation site will contain the 34-foot-diameter gas shaft, and the first modules of the gas treatment plant, steam generation plant, main water treatment and storage facilities, and oil treatment and storage facilities. These facilities will include product gas blowers, a Stretford or equivalent gas treatment unit and associated sulfur storage, product oil treatment and storage, stack, main plant water treatment facilities (including potable water and storage), and the waste disposal facilities.

The mined-shale fill conveyor system will be installed during this stage. The system will provide means to transport and place material from mine development in the Cottonwood Gulch fill area.

A starter dam will be constructed in Sorghum Gulch to provide for impounding water during this stage (see Figure III-B). This containment will supplement the existing Cottonwood Gulch basin. Details of the Sorghum Gulch Dam are discussed in Section II of the DDP.

3. Modified In Situ OXY Process

a. Mine Development and Ventilation

(1) Initial Retorts

The development program will involve the preparation of two full-scale retorts to be simultaneously processed while the development of the commercial panel is still in progress.

Each rubbled column to be retorted will be 200 by 200 feet in plan and 310 feet in height. Only sufficient shale will be removed from within the retort volume to provide an approximate 20% to 25% void to rubble the retort material and to provide a bulked-full retort column. The rubbled shale will be kindled from the top of the retort and processed with air and steam. Oil, gas, and water will be removed from the bottom of the retort. The two retorts will be separated by a pillar.

The present plan calls for a north-south, east-west orientation of the sides of the retorts (refer to Figure III-A). Final engineering design may require that the retort orientation be rotated; however, this is not anticipated. Retort 2 will be located due east of Retort 1. The elevation of the top of the retorts is planned to be approximately 40 feet below the top of the Mahogany zone (see Figure I-D for retort elevations).

The production/temporary gas level will be directly driven along the axis between the 12- and 6-foot-diameter shafts. This connection will provide the ventilation required during the development of this stage. The remaining levels will be driven only a sufficient distance to serve the requirements of the two retorts, as described below.

In order to dispose of the development rock from the upper levels, a waste pass to the production level will be made at the boundary of the 12-foot-diameter shaft pillar.

Process air and steam will be supplied to the retorts by holes drilled into the top of each retort from the air supply level. Voids within the retorts will be created to produce the required void fraction.

Prior to kindling these two retorts, a connection will be made between the 12-foot-diameter shaft station on the production level and the main production shaft/ service shaft area.

After this connection has been made and all of the process installations for the stage have been completed, before the first retort is kindled it will be necessary to install a bulkhead in the production level in order to isolate the gas that will be produced during the retorting process.

For mine ventilation during initial retort preparation it is conceived that, upon completion of the 12-foot-diameter shaft and level and skiploading stations, either the shaft will be divided or an air inlet tube will be installed to carry input air down the shaft to the production level. If a divided shaft is used, a separation wall or bulkhead will be installed from the surface to the production level to allow use of the shaft as a combined downcast-upcast ventilation shaft. Surface fans or blowers will move air down the downcast side of the shaft to the production level where it will be directed through ducting to the working faces. Exhaust air will return via the open drift to the upcast side of the shaft and to the surface. (See Figure III-C.)

The production drift will be advanced to a point directly below the center of the 6-foot shaft location on the surface, and a pilot hole on shaft center will be drilled to the drift below. The shaft will then be upreamed to the surface or down-drilled from the surface. After being lined and connected to surface induction gas blowers, this shaft will be used (upcast) for ventilation during development of the air and rubbling levels used to create the initial retorts. The ventilation system will then become a push-pull system with a surface fan delivering air through the 12-foot-diameter shaft from the surface to working areas through ducting and the induction blowers exhausting air through the 6-foot shaft (See Figure III-D).

When development of air and retort levels are complete and the retorts have been rubbled, stoppages will be installed in the rubbling drifts. The oil-water product-handling systems will be installed on the production-gas level,

and a bulkhead will be installed to isolate the process gas from the 12-foot-diameter shaft and other development and operating levels. The 12-foot-diameter shaft divider can be removed as soon as the production level is connected to the 34-foot production shaft. The initial two retorts can then be kindled to start processing. The 12-foot-diameter shaft will be used for downcast ventilation and for emergency escape during subsequent mine development and operation. (See Figure III-E.)

(2) Retort Clusters

The next step in the development sequence will entail the preparation of one or more retort clusters in the general vicinity of the initial retorts. (See Figure III-B.) These clusters will contain about four retorts.

The development of the full-scale commercial panel will still be in progress, but the main 34-foot-diameter production and service shafts, including all level stations, will now be completed. First priority will be given to completing the drifts required for operation of the retort clusters.

The gas level will be developed from the bottom of the main 34-foot-diameter gas shaft and from a temporary ramp descending from the production level starting at the periphery of the production shaft/service shaft pillar.

Prior to kindling of the first retort cluster, the gas level must be completed. In addition, at all direction change intersection points, stub drives 500 feet long must be prepared to enable the development of additional panels to connect into the gas level. Level development from the bottom of the gas shaft will utilize the sinking hoist facilities for the removal of blasted rock.

The development of the room levels and the air level will take place from the respective shaft stations of the 12-foot-diameter ventilation/escape shaft. The air level will be developed by driving eastwards in the central pillar between the two pairs of retorts in each cluster.

Rock from the upper levels will be dumped down the waste pass to the production level. From here it will be transferred either to the ventilation/escape shaft or to the production shaft and hoisted to the surface for disposal.

Prior to the kindling of the first retort cluster, bulkheads will be built across the production level entry drifts into the retort areas. The necessary oil removal system will be constructed before the bulkhead is finally sealed.

Mine ventilation during the preparation of the retort clusters and during the processing will be similar to the ventilation system employed in the development and operation of the full-scale commercial panel.

The full-size production, service, and product gas shafts will be completed by this time and connections to them on all levels will be driven.

During development, air will be supplied to the mine through the downcast service shaft and the 12-foot-diameter shaft and exhausted through the production level to the upcast production shaft. Fans and ducting will be based at mining levels until adequate connecting drifts and ventilation raises have been prepared to supplant their use in the system. Until the exhaust product blowers are available for use to induce the main air supply through the service shaft, surface ventilation fans will provide fresh air. Surface fans will exhaust the air through the production shaft.

When the retort clusters are completed, air for the retorting reaction will be induced by the first units of product gas blowers on the surface at the outlet of the product gas shaft. Both the service shaft and the 12-foot-diameter ventilation/escape shaft will be available to supply incoming air.

Draft through the retort clusters and product gas system will be created by the product gas blowers. This system will maintain a lower pressure within the gas system and retorts relative to the ambient fresh air system and other mining areas.

Once retorts are processing, spare blower capacity will be provided in case of equipment failure. In the event of power failure, emergency generators independent of the primary power system will be interconnected to service enough of the product blowers, ventilation fans, hoists, and controls to allow a safe and orderly shutdown and to operate bleeder blowers to exhaust residual gases which might continue to be generated within the retorts.

b. Retorting Oil/Gas Processing (Refer to Figures III-F and III-G)

The initial retort process facilities will consist of two full-size commercial-scale in situ retorts and the associated equipment to make the retorts fully operational. Air will be supplied to the retorts from mine shafts and drifts described in subsection a.(1) above. Steam will be piped into the mine and to the retorts from an oil-fired boiler on the

surface that will later be used for utility purposes. Retort products, oil, water, and gas will flow from the bottom of the retorts into a sealed drift. The gas will flow to a dedicated gas shaft and to surface gas treating facilities. Produced oil and water will drain to a sealed sump from which they will be pumped to surface separation facilities.

The proposed surface gas treating facilities will consist of gas blowers, a Stretford-type (liquid phase oxidation) or equivalent hydrogen sulfide removal system, and a thermal oxidizer. These will be designed for the retort product gas. This equipment will be located adjacent to the top of the 6-foot-diameter dedicated product gas shaft.

The surface oil-water separation facilities will consist of primary, settling-type separation equipment followed by an electrostatic oil-field-type heater-treater for final removal of water from the product oil. Tankage for 10 days' production and truck loading facilities will be provided for the product oil.

The initial retort facilities will produce a nominal 2,500 bbl/day of oil for about 7-1/2 months. The retorts will be kindled with reusable oil burners similar to those developed for test retorts on the OXY D.A. Shale property. After kindling, air and steam will be flow-controlled from multiple injection points into the tops of the retorts in the same manner as described for the commercial in situ plant in Section III.E.2.b. Retort product gas outlet instruments and controls will be functionally the same as the commercial design, as will the oil and water liquid collection system and oil-water separation equipment.

Product gas will flow to the surface through the dedicated 6-foot-diameter shaft near the retorts (Figure III-A) that is sized for the initial operation. The gas treating facilities, including the product gas blowers and hydrogen sulfide removal unit, will be functionally the same as and proportioned to the full commercial facilities. The major difference between the initial operation and the commercial plant is the method of utilization of the retort gas product. In this stage, the treated gas will flow to a thermal oxidizer and stack. The thermal oxidizer will convert carbon monoxide, hydrogen, and hydrocarbon components in the gas to carbon dioxide and water. The last traces of hydrogen sulfide will be converted to sulfur dioxide. The unit will be operated at a temperature low enough to prevent the formation of nitrogen oxides.

The facilities for the next stage, retort cluster processing, will be used in the full-scale commercial in situ facilities. This stage will nominally consist of a

four-retort cluster of full commercial-scale retorts and all associated equipment for commercial operation, which can easily be expanded to a larger cluster or clusters, since the associated process facilities will be part of the commercial in situ plant. Air will be supplied to the retorts from the service shaft, and product gas will be routed to the surface through the 34-foot-diameter gas shaft described in 3.a, above.

Process steam will be supplied to the retorts from the first section of commercial boilers fired by retort product gas. The surface gas processing facilities will be located near the top of the 34-foot-diameter product gas shaft and will include the first increment of gas blowers and gas treatment equipment. Oil and water separation and storage facilities will be similar to but larger than that used for the initial retorts.

The ancillary retort cluster facilities are presently planned to produce oil simultaneously from four in situ retorts as a cluster. However, after completion of the initial retorts it may prove to be desirable to revise the number of retorts processed simultaneously.

Operations will be identical to the initial retort stage, except for scale, plant component locations, and the production of process steam from product gas combustion in a boiler. The product gas-fired boiler will operate similarly to the thermal oxidizer in disposing of potential air pollutants by combustion, but in addition, usefully consume a portion of the heat value of the retort product gas.

The surface oil and water separation and liquid product handling and disposition systems will be the same design as in the initial retort operation.

4. Rock Handling and Disposal

Material produced during the shaft-sinking period will be hoisted to the surface, loaded into dump trucks and transported to the construction area, where it will be crushed to specification of a construction fill material required for the surface plant site. (See Figure III-A.) Material produced during the development of stations, access ways, service areas, and during the initial retort development mining will be reduced in size underground and transported to the 12-foot-diameter shaft, hoisted to the surface, loaded into dump trucks, and transported to selected sites to be used as fill for Cottonwood Gulch. For overall program, refer to Section III E.3.

It is planned to use the mined-out shale as construction fill for engineering and for economic and environmental reasons. From an engineering aspect, it will be suitable when properly sized and placed; economically, it will be immediately at hand. If not used as construction fill, it would require disposal to some other location onsite or offsite, and fill needed for the surface plant would have to be imported. Imported fill would represent a cost to the project greater than the value of the oil in the shale when the steps of reclaiming and importation are considered. Environmentally, the use of imported fill would mean disturbance of another source site, and reduced capacity of this site to accept mined-out shale.

Material produced during the development mining of retort clusters will be reduced in size underground in the face area by movable feeder breakers. Run-of-mine material will be crushed underground to a maximum of 6 to 12 inches. The product from the feeder breaker will be transported by belt conveyor system to an underground ore storage at the hoisting shaft. Storage capacity will allow unrestricted operations in the event of delays encountered in the mining, crushing, transporting, or hoisting operations. Hoisted material will be discharged on a belt conveyor system and transported to selected sites to be used as fill for Cottonwood Gulch. Material received from the belt conveyor system will be spread over the gulch areas by a conveyor placement system.

Further details of the overall mined-out shale handling and disposal system are discussed in Section III.E.3.

5. Utilities

a. Electric Power

During the initial retort period, electrical power will be required as outlined in Table III-A. During the initial retort period, power will be generated onsite with diesel generator sets totaling about 10,000 hp. Commercial power supplies are presently being investigated, and will be brought to the tract as soon as all arrangements and construction can be completed. (Refer to DDP III.D.3).

Table III-A - Power Requirements for Ancillary Facilities - Initial Retorts

Facility	Horsepower	Load kVa
General Services		300
Process Blowers	2,000	1,500
Shaft-Sinking	1,500	1,125
Development Drilling	500	375
Development Hoisting	200	150
Ventilation	100	75
Pumping Water and Process	1,000	750
Steam Generation	100	75
Water Treatment	250	190
Gas Treatment	100	75
	5,750	4,615

Electric power during the retort cluster period of ancillary development will be required as listed in Table III-B. During this period of development, onsite power generation capability will be exceeded and it will be necessary to either expand onsite generation or construct power lines to an offsite electrical power source. With the load required during this stage of development, offsite electrical power will be more feasible and efforts will be made to have it onsite as early as possible.

b. Water

Mine dewatering should provide all necessary water for development needs during this Ancillary Development Period. Uses will include dust control, steam generation and other process requirements, and personnel needs. Water will be collected in sumps in the development mining area. This water will then be pumped to the location at which it will be used. Potable water will be piped down from the surface facilities via the development shaft and distributed in pipes to the point of use.

Table III-B - Power Requirements for Ancillary Facilities - Retort Clusters and Development Mining

Facility	Horsepower	Load kVa
General Services		1,200
Hoisting	20,950	15,700
Ventilation	1,000	750
Process Blowers	5,600	4,200
Drilling	1,000	750
Pumping	2,600	2,000
Underground Breaker and Conveyor	1,000	750
Surface Conveying	1,500	1,125
Water Treatment	500	375
Steam Generation	200	150
Gas Treatment	1,000	750
	35,350	27,000

It is likely that a surplus of water will occur during this period. Part of this surplus can be stored in Sorghum Gulch where a starter dam will be constructed to supplement the basin in Cottonwood Gulch, which will be eventually covered. The remaining water may either be injected into subsurface aquifers or treated and released to Piceance Creek. Injection appears to be the most attractive alternative at present.

c. Lighting

High-intensity lighting will be located in and around all surface structures, shaft stations, maintenance facilities, dumping and haulage loading facilities, electrical transformer and switch stations, and office facilities. Active working areas will be properly illuminated. All persons working underground will have their own cap lamps of an approved type to supplement the lighting facilities installed on the mining equipment.

The lights and lighting in the development mine will be designed and installed to meet or exceed all applicable federal and state regulations and requirements.

6. Dams and Water Storage

During shaft-sinking and the initial retort period, a surplus of water of from 100 to 700 gpm is anticipated based on preliminary hydrology (see Figure III-F). This water, depending on final quantity, will be either stored for later use or disposed of by evapotranspiration, reinjection into aquifiers, or treated and released, as discussed in Section II.M of the DDP.

An existing pond in Cottonwood Gulch (see Figure III-A) will provide initial storage for water during development. A temporary impoundment north of the Cottonwood pond at the edge of the tract can also be used to store water, if necessary, until the Sorghum Gulch Dam is constructed or other options, as discussed above, are exercised.

During the first retort cluster period, anticipated water surplus over requirements (See Figure III-G) will be from 500 to 1,500 gpm. Surface storage volume will increase as construction of the Sorghum Gulch Dam and gas treatment area impoundment pond are completed.

a. Sorghum Gulch Dam

During this period, a dam will be constructed in Sorghum Gulch near the northern boundary of the Tract, as shown on Figure III-B. As prescribed in Section II of the DDP, this dam will be of earthfill construction and constructed to a height of approximately 80 feet. This dam will serve as a catchment area for storm runoff directed from the mine surface facilities and as a possible storage dam for groundwater produced from the shaftsinking and the mine development phase. The dam will have a maximum capacity of approximately 600 acre-feet. See Section V-B, Water Pollution Control, for additional information on water containment, treatment, and disposal. The dam site will require approximately 6 acres of land for construction and use during this period. (See Table I-B.)

The dam will enable productive use of the rock excavated during surface facility and mine shaft construction, and will provide a water containment system for storm runoff from construction activity and serve as a storage system for groundwater produced from shaft-sinking and development mining activities.

b. Gas Treatment Area Impoundment Pond

Early construction of this pond, which is to be used ultimately for waste from the surface in situ water treatment plant, will allow its use as additional water storage. (See Figure III-B.)

7. Water Treatment and Disposal

The water treatment facilities for the initial retort period will be located in two areas. The first part of the system will be located near the 12-foot-diameter shaft. The equipment at this location will include filters, the filtered water storage tank, and pumps for gas treatment water and utility water. All other equipment will be located near the oil-fired boiler. See Figure III-A. Methods for water treatment are discussed in Section III.E.9 of this report.

The overall quality of the mine water is quite good; however, the fluoride content appears to be above permissible limits for discharge into the drainage area without treatment.

Methods for disposal or retention of water are discussed at length in Section II of the DDP. They include evapotranspiration, reinjection, defluoridation and release, and storage with eventual use. Of the methods discussed, reinjection appears to merit the most consideration and if injected up-dip would permit storage on Tract C-b.

Current information concerning the actual amount of water is not of sufficient accuracy to enable final plans to be determined at this time; however, this information will be generated during the early development activities.

The water treatment process used during the next period (retort clusters) will be similar to the previous period, but potable water treatment will be added. Added water treatment facilities will be located in two areas. The filtering system will be expanded and remain near the 12-foot-diameter shaft. All other new equipment will be located near the in situ product gas treatment area. Note that the water treating facilities installed in the first period will remain near the oil-fired boiler.

The equipment will be sized for approximately two times the capacity used for the first period. The storage vessels will be sized for final commercial scale requirements.

Water treatment methods for the full-scale facility are discussed in Section III.E.9.

8. Waste Treatment and Disposal

Initial construction of mine development and process facilities will create only a small amount of material for disposal. Site-clearing activities will produce a small amount of soil and slash, which will be stored and used later in revegetation.

Water and liquid wastes from the ancillary process facilities will be impounded for solids settlement, and used for construction of compacted fills and dust suppression. A sanitation collection service will be used during the early development stage to dispose of wastes from shaft-sinking and surface areas. As the job population increases and underground development expands, transition to a packaged treatment plant on the surface will occur. The methods and standards for disposal will be as described in Sections II and V of the DDP.

Waste treatment and disposal for the full-scale facility is described in Section III.E.9.

9. Access and Service Roads

The existing road will be improved to provide an all-weather tract access road to the plant site. It will be necessary to straighten and realign certain sections for safety and design considerations, as well as to clear the plant area. The access road will have a maximum grade of approximately 6% and a maximum curvature of 5% to provide a safe design speed of 55 mph for passenger vehicles.

Preliminary traffic pattern studies estimate that the average daily traffic volume will be enough to require an American Association State Highways and Transportation Officials Type D paved road. Geometric design standards for this type of road require two 10-foot-wide lanes, each with 6-foot shoulders. The total road width will be 32 feet and within the 50-foot guideline set forth in the Lease. However, because the access road to the tract crosses rough terrain, some additional width in the lateral cut and fill slopes may extend beyond 50 feet in order to construct a safe road. The access road improvements during this stage will use approximately 8 acres.

In addition to the main access road, other service roads will be constructed on-tract for access to the various sites and facilities. Wherever necessary, the existing roads will be improved. These roads will be primarily for service and delivery of construction materials and will be of graded dirt and gravel on compacted soil construction. Service roads will require approximately 3 acres.

Total acreage for roads will be 11 acres for the initial retort period activities. (See Table 1-B for total area disturbed by year.) As mine development continues and surface facilities are constructed and expanded during the retort clusters stage, it will be necessary to continue to expand roads. The main tract access will continue to be improved, requiring an additional 20 acres for major road construction. Alignments chosen for these roads will be according to final plant needs to minimize disturbance to the terrain.

Service roads added during this stage will include access roads between the production and service shaft area and the surface in situ plant and gas shaft area and between the gas treatment facilities and Sorghum Gulch to provide access to the dam construction site. Total acreage for roads during this ancillary period will be about 9 acres.

E. Full-Scale Modified In Situ Plant Construction and Operations

1. Introduction and Summary

The construction period of the full-scale commercial facility will begin with shaft sinking in September 1977 and end September 1982 when full-scale commercial operation begins. The start of these operations is defined, for purposes of this program, as the date when the first cluster within the commercial panel is kindled. From this time on mining will no longer be a preproduction activity as part of the construction program; it will then become a production operation. As more clusters are brought on-line production will increase and full-capacity production (57,000 bbl/day) will be achieved in about 12 months, or by September 1983.

Within the 5-year construction period, the ancillary retort facilities will be developed and processed as described in Section III D. The ancillary facilities will use the shafts and some increments of the full-scale oil/gas processing units for their operations.

After key development drifts are driven at all levels around the panel, the principal work of retort preparation will begin in May 1981 and continue to September 1982. The construction of the major oil/gas processing units and general facilities will occur between January 1981 and September 1982.

Operations will continue from September 1982 to about the year 2040, when the resource interval will be exhausted.

2. Modified In Situ OXY Process

a. Mine Development and Design

OXY's modified in situ shale oil recovery process involves the mining of the lowest practical quantity of rock while extracting the highest practical portion of the reserves in a given area. Resource recovery of the modified in situ process is higher than other known methods because of the larger vertical interval of oil shale processed.

The retorting interval of primary interest at the present has a vertical dimension of 310 feet. This interval starts just below the top of the Mahogany zone and ends just above the bottom of the R-6 zone, as shown on Figure I-D. Further details for reference may be found in the DDP (Sections I.D.3 and IV.C.1).

Retorts will be the building blocks of the whole system. As rubbled, individual retorts are 200 by 200 feet in plan and 310 feet in height. Only enough material will be removed from the retort to provide space to rubble the remaining shale into a bulked full column. The rubbled shale will be kindled from the top of the retort and provided with air and steam through appropriate openings. Oil and gas will be removed at the bottom of the retort.

(1) Panels

Panels consist of 32 clusters (8 retorts in a cluster). At the proposed production rate of 57,000 barrels of shale-oil per day, a panel will last for about 4 years. The C-b property encompasses about 11 complete panels, plus some additional groups of clusters (equal to about 4 additional panels) to fill the remaining area. The panels are bordered by 200-foot barrier pillars along and within property boundaries. Drifts within these barrier pillars will be located a minimum of 50 feet from the property boundary.

Orientation of retorts, clusters, panels, and main access openings will be north-south and east-west. This orientation may be changed if actual ground conditions dictate a different bearing.

Individual retorts and retort clusters will be separated by pillars of adequate thickness; the actual thickness will be determined during ancillary development.

Mining levels are identified and described by the functions they serve. From the uppermost to the lowest these are:

- Process air or air level (above the retorts)
- Retort access levels (void excavation)
- Production level (below the retorts)
- Product gas level

(2) Process Air Level

This level serves to carry both the incoming process air to the operating retorts and the mine ventilation air to the mine headings under development. It also serves as an operating area containing process steam distribution lines for retorting and startup burners, air dampers, and related equipment for operating the retorts.

Around the periphery of the panel these air drifts will be 30 feet wide by 30 feet high. Lateral branches serving rows of retorts will be somewhat smaller, as dictated by final equipment clearances and air flows. The lateral branches will be driven above the cluster pillars and will serve two rows of retorts on either side. Air and streams will enter the retorts through entries from these lateral air drifts.

(3) Retort Access Levels

Within the retorting vertical interval (310 feet), voids will be excavated for the sole purpose of providing the required void fraction of the ultimate rubbled retort column. Any access drifts around the panel at these levels will be generally similar and parallel to other levels above and below. This will facilitate the connection of ventilation raises and ore passes.

(4) Production Level

As the panel is being developed and expanded, this level will serve to receive and to transport the mined-out shale from the mine to the production shaft. Under operating conditions, this level will have two functions. The lateral drifts within the panel under the retorts will act as a conduit for product oil, water and gas. Oil and water will flow to the drifts along the outside of the panel through isolating

bulkheads. Drifts along the outside of the panel will contain oil/water gathering and pumping systems and other process operating equipment. This will be a fresh air area since it will be bulkheaded from the lateral drifts within the panel and under positive pressure relative to the laterals.

(5) Product Gas Level

The sole purpose of this level will be to conduct the product gas from the process side of the production level to the product gas shaft and then to the surface. There will be no other connections to any part of the working mine from this level. Under processing conditions, this level will always be under negative pressure relative to all fresh air systems.

(6) Retort and Panel Development

Primary development of the air level will consist of twin east-west headings in the panel barrier pillar from the service and production shafts, a single north-south connection to the 12-foot-diameter ventilation shaft (near the northern property boundary), and a single east-west drift within the northern boundary. Muck will be handled with load, haul, dump (LHD) equipment, feeder breakers, and belt conveyers. The main-line conveyor, which will be in the northernmost drift in the east-west barrier pillar, will discharge into an orepass system, which will transfer the muck to the production level.

Drifts on all these levels will be about 30 feet wide by 20 feet high. Main-line primary development on each level will correspond to that on the air level. Muck from retort excavation will be handled with LHD, feeder breaker, and belt conveyor to the orepass system then to the production shaft. Before being rubbled, the access drift to the development rooms on each level between each retort will be sealed by stoppages or bulkheaded. The openings into each group of clusters from the main-line drifts will be sealed before any processing can take place.

Primary main-line drifting on the production level will be similar to that on the upper levels. Cluster development requires that only access drifts about 30 feet wide by 20 feet high be driven to the vertical centerline under each retort and connected to the retort bottom. LHDs, feeder breakers, and belt conveyors will transfer the material to an ore bin near the production shaft. When rows of clusters have been completely developed, gastight bulkheads will be erected at both the north and south main-line drifts at the junction of lateral drifts within the panel. Oil flowing from retorts inside these bulkheads will be moved to sumps outside the bulkhead and is pumped to a

central reservoir, then pumped to the surface. Process gas travels toward the east-west centerline of the panel where it passes to the gas level below.

The 30- by 30-foot gas level collecting drifts will be below the production level. They will extend in an east-west direction along the center of the panel. The gas will be drawn through the gas shaft by blowers on the surface, where it will be further processed.

The gas level drifts will be extended beyond the point where they will be used for this first panel in the direction of future workings and barricaded. When the future workings connect with the extension, the new end of the gas main will be barricaded and the previous barricade will be removed.

To speed the development of the gas level, a ramp will be driven from the vicinity of the main shafts on the production level to the gas level. This ramp will later be bulkheaded and completely sealed to prevent leakage.

(7) Preproduction Mine Development

The primary level development will be similar on all operating levels. During the shaft-sinking operation, a drift will be driven southward in the eastern barrier pillar corridor on all levels from the 12-foot-diameter ventilation/escape shaft to connect with the production and service shafts. With the completion of shaft-sinking, stub drifts will be driven as required for underground facilities in the immediate area of the production and service shafts on each level. The only difference between the development on different levels will be location and size of excavation for service facilities. Development of the panel will be from east to west. Twin drifts will be driven from the main shafts to the west and within the southern barrier pillar corridor and will reach the fourth or fifth row of retorts. A single drift will be driven within the northern barrier pillar corridor west from the ventilation/escape shaft. Cluster development will begin in the northeast section of the panel, developing the first two rows of retorts in a southerly direction.

Since all muck will be hoisted from the production level, an orepass system is required to transfer the material from the upper level(s). An orepass will be located near the production shaft and will dump directly into the surge bin ahead of the shaft measuring pocket. The orepass raise will be drilled and have an inside diameter of 10 feet. In horizontal retort development, branches will be made at the intermediate levels.

(8) Mining Cycle

Mining will proceed by the conventional room-and-pillar mining cycle of drilling, charging the drilled face, blasting, wetting the blasted rock pile, loading, hauling, scaling, and roof bolting. Roof bolting is expected to be necessary at drift intersections and retort development rooms where back width exceeds 30 feet. All portions of the cycle will be occurring simultaneously in various areas of the mine except for blasting. Blasting will occur during shift changes, at which time no personnel will be in the immediate area of the blast or where there are fumes produced by the blast. All level and room development will essentially conform with drift round procedures.

The first step in the mining cycle will consist of drilling holes for placement of explosives. This operation will be performed with large-scale electric-powered, hydraulic rotary drills, which produce substantially less noise and dust than percussion drills commonly used in underground mines. Water and wetting agents, if required, will be applied at the drill bit for additional dust control. The effect of noise on operating personnel will be minimized through use of sound-insulating cabs on the equipment and muffling of diesel engines where required.

Upon completion of the drilling phase, the holes will be loaded with an explosive mixture.

The blast will produce a pile of broken rock weighing several hundred tons. The pile will then be wetted to minimize dust. The amount of water used to suppress the dust will be carefully regulated to minimize runoff from the pile of broken rock. The broken rock will be loaded into a feeder breaker by large-capacity LHD units. The feeder breaker is the starting point of the conveyor system that transports excavated rock to the loading pocket at the production shaft where it is hoisted to the surface for disposal. Ventilation will be designed to keep dust concentrations within safe levels. If necessary, the equipment will use pressurized cabs to comply with health and safety standards.

After the rock pile has been removed from the work area, loose rock will be removed from the sides and roof of the mine by mechanical scaling equipment. If necessary, the sides and floor will be wetted to control dust to within safe limits. The scaling equipment may also require the use of pressurized, sound-insulated cabs.

When the rooms within the retorts have been excavated, drill jumbos will drill holes in the remainder of the

shale in the retort. These holes will then be loaded and blasted, and with the rubbling of this remaining shale, the mining cycle will be completed.

Several safety constraints have been built into the basic mine criteria. Before any cluster can be kindled, the adjacent clusters must be completely developed. Gas collection will be done in separated, or barricaded, openings from any active mine openings and through a separate level. There will be fresh air openings from any working face to at least two shafts.

A typical panel is shown on Figure I-A. The orientation of this panel may change when more is known of the rock structure at depth. It is planned to develop the area from east to west, driving a north-south drift to connect the production/service shafts with the 12-foot ventilation shaft. Westerly drifts on the north and south edges of the panel will be started and will reach the fourth or fifth row of retorts during preproduction.

Cluster development is expected to begin in the northeast section of the panel, developing the first two rows of retorts in a southerly direction. The third and succeeding westerly rows of retorts will then be developed from north to south.

Kindling will begin with the northeast vertical row of eight retorts, followed by the southeast row of eight, subsequently repeat north south rows will be retorted in a westerly direction.

During this period, the retorts will not encroach upon the initial shaft pillars, as described in III.C.4.g.

(9) Selected Mining Design Criteria

- 350 effective operating days/year
- Three 8-hour shifts/day
- 20 producing shifts/week
- Hoist 7 hours/producing shift
- Mining effective 6.5 hours/producing shift
- Man entry shafts to be downcast air
- Hoist rock from one level

- Shale specific volume 14.78 ft^3/ton in place
- Shale specific volume 22.17 ft^3/ton broken unconfined

(10) Mining Equipment

Most of the equipment selected for the commercial operation will be standard units commonly employed in the mining or construction industries. Specialized equipment such as rock drills, roof bolters, and explosive loaders will be units of proven concept designed specifically for application to the finalized mine dimensions. All diesel equipment will be equipped with catalytic exhaust systems to reduce emissions of hydrocarbons and carbon monoxide.

Most mobile equipment, excluding drill jumbos, that use compressed air or water will have self-contained units with integral air compressors and/or water tanks. This will eliminate the need for extensive lengths of compressed air and water lines and will make the equipment highly mobile so that the required high production tonnage rates can be achieved.

The exact sizes and specifications for the commercial mining equipment will not be known until the completion of geotechnical studies.

(11) Mine Dewatering

Since the shale beds dip at a shallow angle to the northwest, the retort elevations should follow this same pattern in order to maintain the oil shale grade in the retorts. Mine development then will provide a natural drainage to the north. For this reason, the 12-foot-diameter ventilation/escape shaft near the northern property boundary will serve as the main collecting and pumping facility for mine water. Water from the upper level(s) will flow by gravity down the shaft to sumps on the production level, and water from the gas level will be pumped up to these sumps.

There will be three sumps, each with a capacity of 1.5 million gallons. The first will be for the inflowing mine water, the second for decanting, and the third for clear water. Clear water will be pumped back into the mine workings for use in drilling and wetting down. Excess water will be pumped to surface for treatment.

Mine water requirements are estimated to be approximately 1 cfs, or about 450 gpm. This water will originate from the clear water sump of the mine dewatering system and requires no treatment.

Potable water will be piped down the main service shaft and made available on each shaft station level.

Excess mine water pumped to the surface will be stored in surface reservoirs and used in project operation. A certain portion of poor quality water can be used for surface requirements such as dust control. These requirements can be met by mine water without further treatment. A portion of the water will require surface treatment to remove impurities. Presently, excess mine water is expected to be the major source of water for surface operations.

(12) Mine Ventilation System

The air handling concepts proposed must perform dual functions. Fresh air ventilation must be provided for personnel and equipment and air must be provided for retort reactions. Further, the two functions must be separated in such a way that the gaseous products from retorting cannot enter the mine ventilation system.

To accomplish the above objective, a common air source fed from two entries will split underground to supply the isolated reaction section and the mine work areas. The system can be described as a unidirectional modified push-pull system. Air will be supplied to the underground air level through an open downcast service shaft and a downcast ventilation/escape shaft. The air level will distribute air to the retorts in process and to the mining areas being developed.

During retort cluster development, air will be supplied to drift headings using fans and ducts and exhausted through the production level to the upcast production shaft. Main ventilation blowers will be surface mounted at the top of the production shaft to induce ventilation air flow.

As mining advances in the air level, retort access levels (for rubbling), and production level, raises used as muck passes from upper levels to the production level will become available for ventilation use.

When retort development is complete and retorts have been rubbled, stoppages will be installed in the raises and access level drifts, the production level drift will be isolated with bulkheads and connected to the product gas drift,

and the air level will be connected to the top of the retorts. The retort will then be kindled and production will commence.

Product gas blowers on the surface at the head of the gas shaft will induce flow through the retorts and will maintain a lower pressure within the retorts and underground process gas system than in the rest of the fresh air system.

Spare product gas blowers connected to emergency power facilities will be used in case of major power failure to bleed off residual gases and allow a safe and orderly shutdown of the retorts in process. Emergency power will also be available for monitoring and warning systems, lights, ventilation, hoists, and other systems required for safety of mine personnel and equipment.

When each retort cluster starts processing, it will be completely isolated from other retort clusters being developed.

(13) Underground Services

The majority of mining equipment maintenance will be conducted in an underground maintenance facility. The underground maintenance shop will include provisions for overhead crane service, cutting, and welding, and other equipment necessary to assemble and maintain all the mining equipment and associated components required for mining operations. Arrangements will vary for each level, and the size of any given facility will depend on the amount of work established for that level.

Concrete floors will be poured in the maintenance area. Ground control procedures will be intensified in this area, using additional roof bolting, roof mats, chain link fencing, and sprayed concrete, as needed, to ensure integrity of the maintenance facility for the entire mine life. The walls of the shop area will be sprayed with a light reflective coating and high-intensity lighting levels will be maintained in the facility for safety and efficiency.

Ventilation air will be provided to the maintenance facilities in sufficient quantities to maintain safe and healthful working conditions. Exhaust hoods and ducting in individual service bays will remove localized concentrations of contaminants before they enter the main air flow in the shop. Exhaust ventilation from the shop will not traverse other working areas. Included in the design for the underground maintenance facilities is a central underground warehouse facility servicing the requirements of maintenance and mine production.

The maintenance and warehouse complex will be located in close proximity to the service shaft for efficient materials transfer. Trouble-shooting and minor repairs will be done from mobile maintenance vehicles or in temporary shops of limited capabilities located adjacent to active production areas.

The main product oil sump will be located on the production level near the main shafts. This sump will be sealed from the station but vented to surface.

Explosives will be mixed aboveground and transported underground in the service shaft. Magazines will be established on each working level and sized according to consumption. These will be located and constructed as required by applicable federal and state laws. Surface storage and mixing facilities will be provided according to requirements established by authorities.

First aid stations will be located on each operating level. These will include oxygen breathing apparatus and other first aid and medical supplies.

A full-time Safety Department will be maintained. It will be the duty of this department to see that safety regulations are strictly followed.

Portable toilets will be provided in several locations on the different levels. These will be serviced at regular intervals and sewage will be transported to the surface for treatment.

A fully instrumented ground movement monitoring system will be provided.

b. Retorting Oil/Gas Processing (See Block Flow Diagram Figure III-J.)

The construction of the in situ processing facilities during this period will be a continuation of the construction begun under the retort cluster period to bring these facilities to full commercial size. Product liquid and gas-handling facilities will be expanded to support the preparation and operation of 40 in situ retorts operating simultaneously. Oil/water separation equipment will be expanded to handle over 83,000 bbl/day of produced oil plus water, and gas treatment facilities will be expanded to handle over 1 million standard cubic feet of product gas per minute. Steam generation from process gas combustion will be expanded to produce 850,000 pounds/hour of process steam plus utility steam for the gas processing area.

The commercial in situ operation will produce approximately 57,000 barrels of oil per day from a total of 40 operating retorts. The surface process facilities associated directly with retort products include oil/water separation equipment, gas treatment including both product gas blowers and hydrogen sulfide removal, and steam generation from treated product gas.

Process air flow will be drawn into the operating retorts by exhaust product gas blowers, located on the surface, that maintain a negative pressure on the entire retort and gas-gathering system. The air will flow to the retorts from the surface through the service shaft via a network of upper-mine-level air drifts. The drifts will serve as a plenum system for the operating retorts. The process air and piped steam will be mixed in individual feed inlet entries connecting retorts to the air level drifts. The air flow will be regulated into an operating retort by isolating dampers and control on the inlets. Steam will be piped to the operating retorts from steam boilers located on the surface and is flow-controlled into each retort.

A retort will be started by being heated to a kindling temperature by temporary startup burners fueled with raw shale oil. The burners will be set in the inlet air raises and operated until a new retort is heated sufficiently to maintain reaction with the normal air/steam feed.

An operating retort will contain four major zones. In the first zone (at the top), the air/steam feed gas will be preheated by hot spent shale. It will then reach a combustion zone where the oxygen from the air will be consumed by reacting with residual carbon and oil. Below the combustion zone will be the retorting zone, where hot combustion gases will heat the raw shale rubble and true retorting takes place. The kerogen or organic material in the raw shale will be decomposed by the heat to bitumen and ultimately to gas, oil, and solid residue. In the final zone, the combustion and retorting gases will be cooled by the raw, unretorted shale, and oil and water will be condensed.

The product gas, oil, and water will flow out the bottom of the operating retorts. Necessary flow-control bulkheads will be provided at the top or bottom of each operating retort to compensate for uneven reaction in the different section of retorts and in different retorts of a cluster. Gas temperature, flow, and composition will be monitored at the bottom of each retort. A number of other proprietary methods will be used to measure the progress of the retorting front. Produced oil and water will flow through the bottom control bulkheads.

The product gas from operating clusters will be collected in lateral drifts at the bottom, or mine production level. These drifts will be bulkheaded at each end of the panel to isolate them from fresh air operating drifts along the edge of the panel. Within the panel each operating lateral will be connected to the totally isolated main-gas-collection drift below the production level that will conduct all of the product gas to a dedicated gas shaft to the surface.

The oil and water from an operating cluster will flow through a sloped conduit by gravity to the nearest fresh-air end of the lateral drift. They will be collected and transferred on each end of the lateral production-level drift to a central oil/water collection sump from which they will be pumped to surface oil/water separation facilities.

On the surface, free water will be separated from the product oil by gravity in a primary separator. The wet oil will then be pumped to heater/treaters for secondary water separation. The heater/treaters are standard oilfield equipment. They are large horizontal vessels with a heating coil in a small inlet compartment and high-voltage electrostatic grids in the separation section. The oil, or emulsion, is heated and then flows upward through the grids, which puts a static charge on the small water particles causing them to coalesce to large droplets and fall by gravity to the bottom of the vessel. Essentially water-free oil is withdrawn from the top of the vessel and routed to product storage, while water is drawn off the bottom of the vessel and routed to the water-treating plant or pond.

The total gas production from the operating retorts will be routed to the surface in a dedicated product gas shaft. The shaft will terminate at the surface in a blower suction manifold. The product gas blowers will be arranged adjacent to the suction manifold and discharge to the hydrogen sulfide removal unit. Hydrogen sulfide gas will be removed from the product gas stream in a gas treating unit using a Stretford-type or equivalent process. In the Stretford process, hydrogen sulfide is absorbed in an alkaline liquid and directly oxidized to sulfur by dissolved vanadium compounds and an oxidation catalyst.

The product gas blower discharge will be cooled and contacted with oxidized Stretford liquor. The gas will leave the unit and flow to boilers to be burned as fuel. The liquor from the contactors, which will contain suspended particles of elemental sulfur, will flow to an oxidizer basin where it will be aerated to reoxidize the vanadium. The aeration will also float the sulfur to the top of the basin in a foam, which will be skimmed off into a froth basin. The separated sulfur slurry

will be pumped through a sulfur melter into a decanter where liquid sulfur product is withdrawn. The Stretford liquor from the decanter will be returned to the oxidizer basin.

The product gas boilers will be similar to a refinery carbon monoxide boiler, which is designed to be fired with low-heating-value gas. The boilers will consist of a separate firebox to ensure complete combustion and a separate convection boiler section.

Flaring capacity will be provided for 25% of the total design product gas flow. The flaring capacity will be provided for startup and upset conditions. Even in a serious upset, the retorts could be stopped or slowed down by field-perfected techniques. After a shutdown, the retorts could be restarted using techniques perfected during operation of the OXY D.A. Shale retorts.

3. Rock Handling and Disposal

Raw shale produced during the mine development will be placed as fill in Cottonwood Gulch. Refer to paragraph III.D.4 for earlier stages of rock-handling details.

The first portion of Cottonwood Gulch starting from the south end and proceeding north will receive about 25 million tons of mined shale compacted for construction fill (see Figures III-A and III-B). The remainder of the gulch will accept about 40 million tons up to elevation 6,800 feet. Of this total (65 million tons), some 16 million tons will be produced from shaft-sinking and development to the start of the full commercial in situ plant on September 1, 1982. The annual production thereafter, 14 million tons/year, computes to 3.4 years to fill the gulch after start of full-scale in situ production, allowing for property boundary setbacks and surface drainage systems.

Sorghum Gulch has a net capacity of some 212 million tons computed to elevation 7,000 feet allowing for dam, water storage, and drainage systems. This is about 19 years of full production.

The combined capacity of both gulches is about 22.4 years from September 1, 1982, or until early in year 2005. Other minor and major gulches on the property, including Stewart and Scandard, have an additional capacity, if needed, of some 600 million tons, or about another 40 years. This is a total of 60+ years filled to bordering ridges without exceeding the ridge elevations of the property.

Several alternates to the use of Stewart and Scandard Gulches are also available. One is to continue to fill above the general elevation of the site in several localized areas as proposed in the DDP. At the same average land usage of 1,100 acres and 336,000 tons/acre described in the DDP, about 30 years of production of this plant capacity is available. These piles would be from 100 to 200 feet above the surrounding terrain.

Another potential alternate would be to return the shale underground to the voids in the retort panels after the panels are exhausted. It seems reasonable that within the 22-year period before Cottonwood and Sorghum Gulches are filled, detailed techniques for returning this material underground will be developed. The shale would be in a form that could be transported and placed as a slurry using circulating water as a vehicle, most of which could be recovered from each cycle.

Besides the advantage of returning the material underground, this method would reduce the need for much of the revegetation required for surface disposal of shale. It would also eliminate the requirement for continuously applied water during revegetation.

Mined shale will be transported to the surface through the production shaft. This material will be transferred onto a covered belt conveyor system, moved to selected areas in Cottonwood Gulch and spread over these sites by a conveyor placement system. The shale will be crushed to a size suitable for the degree of compaction required for pile stability, drainage and revegetation. Each selected area will be built up in layers to its final height before shifting the conveyor placement system. The areas will be large enough to allow a practical conveyor system design and operation but small enough to allow revegetation to begin as soon as a segment has been filled.

Since no spent shale will be disposed of on the surface, the special problems associated with spent shale will not exist. Before any fill is started, top soils in fill areas will be stripped and saved for later use as fill cover to facilitate revegetation.

The quantitites of mined out raw shale on a daily basis will be 41,000 tons vs 66,000 tons of spent shale in the DDP. This reduction will also facilitate placement and revegetation.

Dust-control methods will be applied throughout the handling and placement of the mined-out shale. Since this material already contains moisture, there will be less demand for initial water than equal quantities of spent shale. The mined-out shale will be placed in such a manner that it may

later be reclaimed for further processing, if economics indicate this to be feasible.

4. On-Tract General Support Facilities

In this period, the surface support facilities will be expanded to final plant size and sited in the final plant configuration and location (see Figure III-H). These facilities will include the following:

(1) Mine support facilities at production and service shaft area: Offices, changerooms, maintenance shops, mine warehouse, mine substation, mined shale handling and conveyor loading, product oil handling and storage, utility steam generation and feedwater treatment, and underground waste disposal facilities.

(2) Mine support facilities at 12-foot-diameter escape/ventilation shaft: Facilities for storage and filtration of water from mine dewatering, and distribution pumping station.

(3) Mined shale conveyor, storage, and transfer system: Conveyors, stacker, transfer, and substation.

(4) 34-foot-diameter gas shaft and gas treatment area: Production gas blowers, Stretford type sulfur recovery system, process steam generation and steam water treatment, product oil treatment and storage, offices, changehouse, laboratory, substation, maintenance and warehouse facilities, process waste water storage and sanitary waste treatment facilities.

(5) Impoundments and dams: Cottonwood Gulch impoundment pond and Sorghum Gulch water storage dam and impoundment area, and substations.

5. Off-Tract Facilities

a. Staging and Terminal Facilities

The planned staging facility is expected to be the same as described in the DDP Section III D-1.

b. Water Supply Facilities

There is no change in plans set forth in the DDP, as described in Section III.D.2.

c. Electrical Transmission

Electrical power required for operation of on-tract facilities will be purchased from off-tract Public Utility companies. The power will be brought to the tract by electrical transmission lines owned and operated by the Public Utility. Possible powerline corridors approaching Tract C-b are shown in Figure III-K.

The 7.2-kV single-phase Public Utility line that presently exists on tract C-b has insufficient capacity for ancillary development power requirements. It is possible that the Public Utility could install new conductors on this existing powerline for a maximum capacity of 10,000 kVA. This would be less than 10% of the commercial operation requirements, but would meet this early stage power requirements and provide an alternate to on-tract-generated hoist power.

The 138-kV transmission line from White River Electric Company has a probable capacity of 190,000 kVA; however, all but 20,000 kVA of this power is spoken for by other customers. The power obligated to other customers on the Colorado Ute Electric Company lines along Sheep Creek is unknown, but it is fairly certain that the total power requirement from tract operation, as shown in Table III-C, is greater than the power available from any of these lines.

Colorado Ute Electric Company is planning a new line of either 230 kV or 345 kV from Craig to Rifle. The voltage chosen will depend upon the commitments of potential customers. The power required for Tract C-b would be a significant load on this transmission line.

The construction of a full-capacity electrical transmission line on to Tract C-b will require about 2 years for design and construction. On-tract facilities will utilize the existing line plus on-tract generation until the line is completed. The on-tract generation equipment used during construction and development will be retained as emergency backup during full-scale operation.

Other conditions as stated in DDP V.M still apply.

d. Communications

Communications during this period will be expanded to provide for construction needs.

Plans (as described in DDP III.D.4) will be unchanged and will include an anticipated telecommunication duct or microwave system.

e. Roads

There is no change in the preferred off-tract primary road corridor, as described in DDP III.D.5.

f. Pipelines

(1) Pipeline Corridors

The pipeline corridors described in Section III.D.6 of the DDP still apply. However, for reasons mentioned in Section I, it is necessary to look for an alternate oil pipeline route that considers potential supply-demand changes that may take place when Alaskan crude starts to arrive on the west coast.

The alternate oil pipeline corridor would extend generally north and east from Tract C-b and connect with an existing pipeline in the vicinity of Casper or Guernsey, Wyoming. This route would have the ability to supply the northern tier and central states with a secure domestic source of oil. If White River water is used, this corridor would also be used to supply water to Tract C-b.

Although a detailed study of this route has not been made, it would generally follow existing pipeline routes. A schematic of the route is shown in Figure III-L.

(2) Product Oil Pipeline

The aspects of pipeline design contained in Section III-D of the DDP still apply.

(3) By-Products Pipeline

By-product pipelines are no longer being considered because of the limited by-products and volumes associated with modified in situ retorting.

(4) Operations

Operations, maintenance, and oil spill contingency planning are described in Section IV(J) of the DDP. No changes are anticipated as a result of this new plan for development of Tract C-b.

6. Utilities

a. Electrical

Electrical power requirements for mine and surface in situ facilities are shown in Table III-C. Construction of listed facilities not already installed will take place during this period.

Table III-C. Power Requirements for Full-Scale Commercial Facility

Facility	Estimated hp	Estimated Load kVA
Underground Mine		
Hoisting	20,950	15,700
Drilling	7,000	5,200
Ventilation	3,600	2,700
Dewatering	4,400	3,300
Breaking & Conveying	2,500	1,875
Product Pumps	6,400	4,800
General Services		1,200
Total	44,850	35,075
Surface In Situ Plant		
Gas Treatment	12,000	9,000
Product Oil Treatment	4,000	3,000
Steam Generation	800	600
Process Blowers	66,800	50,100
Water Treatment	6,200	4,650
Sulfur Recovery	2,000	1,500
General Services		2,500
Total	91,800	70,350

Limited temporary power for construction needs will be required and can be provided from the existing mine development facilities.

The two broad areas for power consumption are: (1) The underground mine and mine support facilities, and, (2) the surface in situ gas and oil treatment plant. These facilities require only additional expansion with an associated increase in power consumption.

The surface-located hoist shaft area substation will provide feeders and motor starting control to the hoists, mine, ventilation fans, mine dewatering pumps, and surface dumping installations.

Underground mining loads will be connected to permanent mine facilities substations located on the individual levels in the shaft station area. Low-voltage auxiliaries for underground mining, ventilation, and lighting will be supplied from portable (skid-mounted) mine-type substations.

Electrically powered, hydraulically driven drilling equipment, feeder breakers delivering mined shale to the conveyor system and portable ventilation fans will be the major demand units in the mining operations.

The underground installation will be provided with portable substations directly connected to the mine switchgear, No. 1 and No. 2 feeder controllers, at the Hoist House swtichgear room. Feeders will be run in one length to the place of their initial location and terminate in a control interlocked coupler.

Portable substations will be suitable to supply power to motors, lighting, heating and ventilating, and all the electrical requirements for the 480-V and 120-V systems. Motors of 200 hp and larger will be directly connected to the 4.16-kV motor controllers located above ground.

A stock of cable will be used as extensions for substations and/or equipment units that are moved along the underground grid.

The system design and hardware components will meet all applicable federal and state regulations for underground nonmetallic mines.

All personnel underground will have personal cap lamps of an approved type to supplement the lighting facilities included in the mine and on the mining equipment.

The lights and lighting in the mine will be designed and installed in such a manner as to meet or exceed all applicable federal and state regulations and the lease requirements.

b. Fuel

The fuel system is the same as described in DDP Section IV.C.10.

c. Steam System

Steam for in situ process requirements using offgas from underground retorts will be in addition to the description in the DDP IV.I.2. The in situ process will require approximately 850,000 lb/hr of steam at 450 psig, superheated to allow distribution dry to the underground retorts.

d. Compressed Air

Air for construction use will be provided by mobile compressors. Plant air, utility air, and instrument air will be provided as required by local compressor installations.

e. Communications

Telephone and/or radio installations will be provided for outside communication. A complete internal telephone network will be established to connect all parts of the surface and underground facilities.

A PBX multistation telephone communication system will be provided for offsite and inplant communications. This system will be supplemented by a duplicate hard-wired system for underground and underground-to-surface communications.

Duplicate alarm systems for system failures, mine blasting warnings, and similar alarm conditions will be installed in the underground areas. These alarms will include audible, olfactory, and visual alarms.

Radio communications will be installed to provide contact between mobile equipment and the communications center, as well as provide a backup for the other systems.

f. Water

Water will be required for construction dust control, compacted fills, and concrete work. The anticipated quantities will be readily available from mine dewatering. Potable water for construction use will be available from development water treatment facilities. Plant facilities to be constructed will be as described in Section III.E.8 of this report.

Drinking water for mine employees will be piped underground from the surface water treatment facilities to the underground maintenance shops. The facility will be served by appropriately located industrial drinking fountains. Potable water for the employees working in production areas or other areas remote from the shop facilities will be supplied in insulated dispensing containers and will be replaced once per shift by assigned personnel. One-use drinking cups will be maintained at all supply points of potable water; suitable disposal containers will be appropriately located.

g. Fire Protection

Fire protection will be an important aspect of the underground operation. Although it is not anticipated that the mine will be classified as "gassy" in the usual interpretation, there will be gases produced by the underground retorting process. These gases will be completely contained within the retorting system because of the negative pressure of the gas removal system. However, because some of the gases are flammable and toxic, an adequate fire fighting system will be maintained. For other parts of the mine, connections to water lines will be strategically located. Every item of equipment will be provided with a portable fire extinguisher. Specially appointed fire fighting vehicles and chemical carts will be provided in various locations. An alarm system,including an olfactory system for the ventilation air, will be provided. Oxygen breathing apparatus and trained crews will be available and every man will carry a self-rescue device. All personnel, especially supervisors, will be thoroughly trained in fire control and mine evacuation procedures.

7. Dams and Water Storage

The major water containment structure, Sorghum Gulch Dam, should be completed at this time. The full storage capability of 600-acre feet of water can be used, if required.

Additional preparations for control of rainwater in the Sorghum drainage area and of shale disposal runoff and seepage will be started.

A coronation diversion system will be used to divert rainwater around the shale disposal area and into the dam impoundment. Additional catchment ponds may be installed above the Sorghum Reservoir to capture sediment from the shale and prevent it from reaching the reservoir.

Water from the catchment ponds will be used to supplement needs for shale dust and compaction control.

It may be found necessary to retain and make permanent the Cottonwood Gulch temporary impoundment pond constructed earlier to collect runoff from the plant area drainage system. This water, depending on quality, would either join the Sorghum Reservoir water or be added to the lower-quality water for shale use.

The lined pond adjacent to the gas treatment area would revert from general water storage use to its final service as containment settling and concentration area for product water and process blowdowns.

8. Water Treatment, Use, and Disposal

One of the main sources of water to support project needs is envisioned, from preliminary hydrologic investigations by OXY consultants, to be from mine dewatering. It is anticipated that the amount of water available from the mine during development of the commercial plant will be more than required during the early stages and somewhat less than required after commencing full-scale operation.

Early investigation prior to initial development will define these estimates more precisely.

Comparison of Water Availability and Use

Status of Mine and Process Plant	Estimated Mine Water Available (gpm)	Estimated Mine and Process Water Usage (gpm)
Initial Retort Development	400 - 1,000	310
Retort Cluster Development	800 - 2,000	460
Commercial Operation	2,000 - X	2,500 gpm

From the above tabulation it may be seen that water needs during plant commercial operation are estimated to be 2,500 gpm. Usage of water in the DDP showed a net plant requirement of 5,500 gpm (see DDP Figure IV-29).

Treatment of the mine water depends on the use of the water. Major uses include:

(1) Untreated raw mine water: Dust suppression underground.

(2) Filtered raw water: Feed for other treatment, utility service, fire protection and construction.

(3) Treated water: Steam generation, process cooling, potable water for personnel use, and for discharge from tract.

(4) Water treatment and process effluents: Dust suppression and compaction moisture for shale.

Water for underground drilling and dust suppression can be used directly from collection and settling sumps in the mine with no treatment. All water pumped from the mine to the surface will be clarified and filtered. Filtered water will be stored and transferred as needed directly to further treatment for other uses. It is planned that boiler feedwater will be treated by addition of chemicals for scale control, subjected to reverse osmosis to reduce dissolved solids and then deionized and deaerated. Potable water will likely require treatment by reverse osmosis, activated alumina filtration (to remove the fluoride ions), and chlorination before use. Various waste effluents from filtration, reverse osmosis, deionizing, and alumina filtration will be collected in a sealed settling pond and used to control moisture of shale for dust suppression and compaction control. Some evaporation and sludge settlement will occur in this pond as well.

The use of water during normal operations will total 2,500 gpm for the combined mining and in situ retorting plants. During construction, 500 to 750 gpm of water will be required for concrete manufacture, dust control, compaction of grades and fill, and other general and personnel uses.

All water supplied to the process plants will eventually be consumed or recycled or released to the atmosphere by evaporation. A major consumptive use of water is the moisturization of shale, for which all waste water streams not otherwise recycled will be used. Water used for moisturizing shale for reclamation or for dust control will either evaporate, be permanently incorporated into the waste pile, or drain into the

catchment basin for recycle. Other consumptive uses include steam generation in both the in situ and surface retorting plants for heating and process requirements, use as drinking water, evaporation losses and use as irrigation water in revegetation.

9. Waste Treatment and Disposal

During the construction period for the in situ facilities, small additional quantitites of slash (small trees and brush) will be generated from surface clearing for site preparation. This material and other construction wastes will be handled as specified in DDP Section V-I.

During the operation of the full-scale plant, the wastes will be from two major sources: process wastes and sanitary wastes.

For the most part, process wastes will be generated from water and oil treatment systems and other blowdowns. Water treatment sludges will be ponded for evaporation, neutralized and either combined with the mined-out shale in solid form, returned to the spent retorts, or disposed of offsite in an acceptable manner.

Sanitary wastes will be treated onsite, recovering liquid values for reuse and disposing of solids along with process solid waste materials.

It is not anticipated that any waste streams pose a special problem. All treatment systems are expected to be conventional with precedence of acceptance within existing environmental and other regulations.

10. Roads

Final construction, realignment, and paving of the tract access road will be completed early in this period. It is expected that traffic density will be such that the need for final paving will be required at this time.

Additional in-plant service and access roads will be minimal during this period. It is anticipated that the only new roads to be added will be a graded dirt access to the relocated Cottonwood Gulch impoundment pond and conveyor service roads. Tract access roads will require 25 acres of surface during this period.

11. Postoperations

Decommissioning of the plant and rehabilitating of the site are discussed in the DDP, and apply to this mining and retorting scheme where comparable.

The processed shale remaining underground will have been treated according to methods described in Section V of this DDP Modification.

IV. OPTIONS AND ALTERNATIVES

A. Introduction

Several options may present economically attractive alternatives as a supplement to the basic program described in this DDP Modification. The principal options envisioned at this time are:

- Surface Retorting of Mined-Out Shale
- Onsite Electric Power Generation from Low-Btu Product Gas
- Alternative Water Supply and Management

Each of these cases is highly dependent upon economic and technical factors that cannot be determined at this time. However, considering the length of the program, it is conceivable that many of these factors will become definable, resulting in an alternate course that will be advantageous to the program.

B. Surface Retorting Option

A companion surface retorting facility to process shale mined out from the in situ facility would be required to process about 41,000 tons/day, or 62% of the feed rate described in the DDP.

Due to technical and economic uncertainties, surface retorting is not being considered in the DDP modification. The Lessee plans to continue to investigate surface retorting so that provisions in the in situ facility development will allow consideration of surface processing at a later date. Any plans to include surface retorting will be presented to the AOSS for approval. In the meantime, the mined-out raw shale placed on the surface will remain as a resource accessible for surface retorting in the future.

C. Onsite Power Generation

The base plan is to generate steam from the low-Btu product gases as required for the process of in situ retorting.

Electric power would be imported. There is sufficient heat remaining in the combusted gases from the low-Btu boilers to extract considerable energy for electric power generation.

Preliminary evaluations indicate the potential for onsite power generation might be considered at several levels. One case would be to generate all process steam plus all onsite power demands. Another would be to produce process steam plus onsite power and to export additional power up to the limits of an economic system. Both cases involve the application of combined-cycle systems.

The potential for exported power after satisfying the demands of all on-tract consumers would be in the range of 300 to 400 MW, using a combination of low-Btu boilers, gas turbines, waste heat boilers, and steam turbines.

D. Water Supply and Management

Water supply, use, treatment, recovery, and disposal are heavily dependent upon the quantities to be encountered underground. Estimates from hydrology studies vary by an order of magnitude. The most conservative estimates indicate a slight deficiency and the most liberal show an excess.

There will be two principal water sources. The primary source will be underground water recovered from the mine dewatering operations. The quality of these waters varies depending upon the depth where they occur. Treatment will depend upon final use. Some water may be used directly without treatment for drilling, dust control, etc. Boiler feedwater will require fairly extensive treatment. General utility water will require somewhat less treatment.

A secondary source will be the product water formed in the retorting process. Because of the high level of impurities this water will require relatively extensive treatment. This treatment will be reduced to the extent that minewater is available to displace it as a water source. In the event that no product water is required for high quality uses it may be ponded, evaporated, used for dust control or returned to spent retorts. Product water will be returned to a spent retort only if it will not pollute water supplies. As a final resort, excess product water can be treated and discharged. Should a significant deficiency of source water from mine dewatering be the case, water may either be imported from off-tract, or onsite wells might be used. Should a large excess of mine water occur, this may be ponded, reinjected, or treated for disposal off-tract. In any case, excess water streams will be treated to an acceptable extent, in accordance with applicable regulations prior to disposition.

Information on hand indicates that at least for the early stages during the ancillary development there will be water in excess of requirements. This will allow time for decisions for off-tract pipelines and outside source requirements based on more precise data.

V. ENVIRONMENTAL CONTROL PLANS

As described in Section III, the OXY-Modified In Situ Process will be used to extract oil from oil shale instead of the sequence of mining shale by room-and-pillar methods, retorting the shale above ground, and then disposing of processed shale on the surface, as was described in the DDP. This change in methods is reflected in some of the environmental control plans.

The following discussion focuses on aspects in which the control plans for the revised approach differ from the plans in the DDP. The dimensions or elements of the control plans in the two cases are the same, however. Thus, for ease in comparing the two cases, the subsections that follow are in the same order as in the DDP.

A. Air Pollution Control

The DDP discussed air pollution control plans in four phases: (1) mine development, (2) plant construction, (3) plant operations, and (4) postoperations. The provisions for air pollution control described for phases (1), (2), and (4) in the DDP are also applicable for the revised scheme. The provisions for air pollution control for plant operations must be examined since a new process (the modified in situ process) is being introduced, while the surface retorting operation is being omitted.

Air pollutants emitted during plant operations from the modified in situ operation are the same as those described in the DDP. These critical emissions are particulates, sulfur dioxide, carbon monoxide, total hydrocarbons (THC), and oxides of nitrogen. Table V-A shows these emissions calculated for the DDP and modified in situ operation.

Calculated emissions from the in situ operation are based on the combustion of the offgas after hydrogen sulfide has been reduced to 15 ppmv in a Stretford type plant. Removal of hydrogen sulfide to this level and lower has been demonstrated in several Stretford commercial plants operating on Claus tail gas. Combustion efficiencies are based on tabulations for gas-fired boilers by the Environmental Protection Agency, AP-42, Compilation of Air Pollutant Emission Factors.

Table V-A - Commercial Plant Emissions

Emissions in Pounds/Hour			
Pollutant	Orig DDP*	Modified DDP	Stack Ht, Ft
Particulates	361	<74	<414
SO_2 I	314	174	-
II	251	174	<414
CO	511	84	<414
THC	353	15	<414
NO_x	1,996	588	<414

Basis: In situ emissions estimated from offgas composition.

Assumptions: The Stretford plant emits 15 ppmv H_2S maximum.

Emissions from thermal oxidizers or from steam generating plants using in situ offgas can be estimated from EPA AP-42 in proportion to higher heating values for gaseous fuels (used by EPA on page 1.5-2).

No fuel burning above combustion of offgas is required for power or heat.

*In response to comments received on the DDP additional air diffusion modeling was accomplished. A report dated November 1st 1976 was submitted to the AOSS. This report establishes the basis for the emission levels listed.

For all pollutants, emission from the in situ plant are clearly less than from the original plant. Thus, any stack height originally determined to be suitable for those pollutants will be more than adequate for the revised emission levels. The exact design will be a function of some economic tradeoffs concerning the number and location of stacks to serve various units that produce atmospheric exhausts. Costs of manifolding, pressure drop, etc., versus construction costs will have to be weighed.

There may be an advantageous plume rise gained from the greater volume and heat of exhaust from the modified in situ operation. This exhaust is very dilute in pollutants, so its volume does not lead to excessive pollution. However, the exhaust carries considerable heat compared to air by virtue of its volume, and this heat causes the exhaust to rise more than was considered in the DDP. Additional plume rise can be substituted for stack height, thereby allowing shorter stacks to be built without jeopardizing air quality standards.

In addition to plume rise enhancement from the larger volume of exhaust, there may also be enhancement by the exhaust being hotter than projected in the DDP. The amount of this latter enhancement cannot be specified until decisions are made regarding recovery of waste heat from the exhaust. Any excess temperature present in the exhaust, however, will further reduce the stack height required.

Also the revised development plan involves only 62% of the original daily tonnage of mined shale. Thus, the daily production of fugitive dust from handling this material will be significantly less. The daily production of fugitive dust is also significantly lessened by omitting both shale crushing preparatory to surface retorting and the handling of processed shale.

Finally, detailed air pollution modeling will be performed for each phase of the proposed project as part of the permit process. Since all of the steps before the full commercial operation are of much smaller scale (5% to 10% or full scale), it is clear that stacks can be designed for these early operations that will allow air quality regulations to be met.

B. Water Pollution Control

Water pollution control plans in the DDP are discussed in terms of control activities during construction, mining, processing, handling of mined shale, and operation of offsite facilities. The plans described for these activities are applicable for the revised mining and retorting scheme. In addition, spent in situ retorts must be kept from serving as sources of water pollution, as follows.

Depending upon the retorting temperature, processed shale in spent in situ retorts consists either of a matrix of oxides of calcium and magnesium or of igneous, insoluble minerals (personal communication, Ward Smith, Laramie Energy Research Center). The oxide matrix may contain salts that could be leached if water should come in contact with them. Three approaches to keep such leaching from resulting in ground water pollution are (1) deliberate leaching, with retrieval of the leachate, (2) diversion of potential leachate by design of the outer areas of the mined area, and (3) isolation of retorted shale from potential leachate. These approaches are being studied at OXY's D.A. Shale Project to determine which methods are most practical, and the most viable plan for Tract C-b will be submitted. With regard to water quality, refer to page II-45 of the DDP. Additional data will be obtained in conjunction with the core drilling program starting in February 1977.

C. Noise Control

The noise control plan in the DDP is applicable to the revised mining and retorting scheme. In addition, consideration must be given to the effects of large blasts used to form the in situ rubble piles, as follows: Blasts used to form in situ rubble piles are larger and release more energy than the blasts contemplated in the DDP. Similar blasting has been used in OXY's D.A. Shale Project, and the results can be extended to the C-b site. The noise level at the surface is not a problem. Moreover, at distances farther away than 500 to 600 yards, a person cannot usually hear the blast.

Also, vibration analysis indicates that blasts used to form in situ rubble will not present seismic problems at Tract C-b to either ordinary structures or equipment at a distance of 400 yards or more. Installations closer than this distance all lie within the tract boundary and will be built to withstand the blasts.

D. Protection of Objects of Historic or Scientific Interest and Aesthetic Value

The plan to protect objects of historic, scientific, or aesthetic value presented in the DDP is applicable to and adequate for the revised mining and retorting scheme. No changes are envisioned.

E. Fire Prevention and Control

Fire prevention and control plans are described in the DDP in terms of construction activities, mine operations, and above-

ground plant operations. The plans presented in these discussions also apply to the revised mining and retorting scheme.

Modified in situ retorting involves controlled chemical reactions. Reaction rates depend upon the rate at which oxygen is supplied, and the air flow to an in situ retort is therefore carefully regulated. In the event that there is a problem with a retort or any of its appurtenances, it can be extinguished by closing off its air supply. An extinguished retort can be restarted when appropriate if retorting has not already been completed.

Retort reactions are confined to the rubbled shale and cannot escape because the shale pillar is too impermeable to allow air to penetrate more than a few inches into the surface. Moreover, the heat capacity of the shale is too high to reach reaction temperatures more than a few inches beneath the surface when the oxidation is only at the surface.

A further safety provision is to operate an in situ retort under negative pressure relative to ambient conditions. This arrangement causes any leaks that might occur to be into the retort instead of into the surroundings. Thus, flammable gases will not escape from a retort into the surrounding mine.

See also Section III.E.2.

F. Health and Safety

The DDP contains provisions for the health and safety of workers on the project. These provisions apply in general to the revised mining and retorting scheme. In addition, the preparation and the operation of modified in situ retorts present two other considerations for health and safety, which are discussed in this section.

The first consideration is stability of the mine. The modified in situ process affords leeway in selecting the mining zones and allows mining to be done in stratigraphic zones that provide competent mine roofs. The initial shaft will provide data for the selection of mining zones, and the ultimate mine design will take account of these data.

It should be noted that properly selected roof zones at OXY's D.A. Shale Project have been opened to greater than 25,000 square feet and have remained stable for the time required for retort development. This is larger than any spans envisioned for development of Tract C-b. It indicates, however, that manways and airways as wide as 30 feet will remain stable for many years without excessive artificial support.

A further point regarding stability is the fact that the rubbled retorts are bulked full of rubble. Thus, loads are supported throughout the retort, not just on pillar sections. This reduces the stress on any individual cross section and leads to greater mine stability than would exist with conventional room-and-pillar mining.

The second consideration is ventilation. Ventilation problems inherent in large cross-section openings for room-and-pillar mining are largely eliminated in the ventilation systems used for the modified in situ mining system. Full-drift air passage is provided by the vertically connected multilevel developments that are used to create the retorts. Cross-entry brattices or stoppings, which are difficult to maintain, are thereby obviated.

As mentioned in Section V.E, the retort is operated at a negative pressure relative to the atmosphere, thereby keeping retort gases from leaking into the mine. Moreover, retort offgas is drawn out the bottom of the retort in a dedicated gas drift separate from all other mine workings. This drift is far enough away that the rock, which has very low permeability, will isolate the gas drift from the mine. Two other means for keeping retort gas out of the mine are (1) sealing connections to the retorts with inlet air under greater pressure than in the retort and (2) providing backup fans and standby power in the event the main fans do not function.

In addition to the above provisions for keeping noxious gas out of the mine, carbon monoxide, methane, and hydrogen sulfide monitors will be placed throughout the mine. The oxygen level will also be monitored throughout the mine. These monitors will be equipped with audible alarms as well as be connected to control rooms in order to warn of any impending dangers.

G. Overburden Management

The DDP describes overburden management in terms of overburden properties, excavation procedures, conservation of topsoil, stockpiling, and stabilization and rehabilitation. These provisions also apply to the revised mining and retorting scheme. See Table I-B for a tabulation of disturbed areas.

H. Raw Shale Storage

The DDP provides for the disposal of processed shale in Sorghum Gulch. The revised plan provides for raw shale storage in these areas. The amounts involved are different and some adjustments must therefore be made, as follows.

The daily production of raw shale in the revised scheme is 62% of the daily production of processed shale in the original scheme. However, the total production of shale is 725 million cubic yards for the revised scheme vs 370 million cubic yards for the original scheme. The difference results from vastly different project lifetimes.

In the revised scheme, it will take until approximately 2005 for Sorghum Gulch to be filled to the existing ridge line. This assumes that no disposal occurs off-tract. At this point, several alternatives are possible: (1) Sorghum Gulch can continue to be used on-tract to store shale, raising the disposal pile to 200 feet above the ridge line, as in the DDP; (2) shale can be placed in Sorghum Gulch off-tract to the south (if land use rules permit); (3) shale can be placed in Scandard Gulch or in the West Fork of Stewart Gulch (on-tract); (4) shale can be placed above the ridge line in Cottonwood Gulch; and/or (5) shale can be placed underground in the voids. It is too early to decide which alternative or combination of alternatives will be considered best in year 2005.

The raw shale storage pile(s) will be constructed and stabilized as described in the DDP for the processed shale disposal pile. Every practical effort will be made to develop the pile in relatively small sections that are brought to full height and vegetated as soon as possible. This will minimize the extent of unvegetated shale at any one time and the concomitant potential for fugitive dust.

Raw shale is brought to the surface in the course of forming in situ retorts. It is desirable to be able to store the shale so that it resembles its surroundings, and this typically involves vegetating it. Revegetation of spent shale dumps has been adequately demonstrated by others. The revegetation of raw shale by comparison is a less difficult exercise. Experiments on raw shale were implemented in the D.A. Shale project in June 1976. These tests show that plant material can be easily established. The experience gained from this small test will be utilized in developing a permanent trial plot in 1977. This plot will demonstrate the most practical method for revegetating raw shale. The following is a list of major items to be investigated:

(1) Particle size and soil compaction.

(2) Leaching requirements.

(3) Minimum requirements for plant nutrients and most effective method of application.

(4) Necessity of seed bed mulching.

(5) Minimum irrigation requirements and frequency.

(6) Plant material combinations.

(7) Optimum planting time and methods (seeding vs vegetative planting).

(8) Weathering of shale waiting to be vegetated.

In conducting the experiments, attempts will be made to identify combinations of the above variables that minimize the effort and expense needed to achieve satisfactory plant growth. The goal is a heterogeneous mixture of vegetative types.

A preliminary time table for revegetation of raw shale dumps on tract C-b is as follows:

Year 1

- Removal and storage of high grade top soil ahead of shale dumping.
- Disposal of raw shale.
- Compact, contour and shape pile.
- Top with selected raw shale material or available existing surface soil that was set aside.
- Irrigation
- Prepare seed bed
- Planting - in time to establish seedlings before first fall frost.
- Mulch seed bed as required with reserved top soil.
- Apply controlled sprinkler irrigation, including injection of soluble nutrients as required.
- Environmental and plant growth monitoring.

Year 2

- Irrigation to continue to establish plants based on soil moisture and environmental conditions.
- Continue soluble fertilizer application with irrigation according to plant analysis and growth response.
- Environmental and plant growth monitoring.

Years 3 to 5

- Late summer or fall irrigation, if necessary.
- Annual late fall application of fertilizer.
- Environmental and plant growth monitoring.

I. Disposal of Other Wastes

The DDP discusses waste disposal in terms of solid and liquid wastes from shale pyrolysis (retorting), shale crushing, oil upgrading, gas treatment, water treatment, and miscellaneous activities normally associated with a large manufacturing facility. With the exception of shale pyrolysis, crushing, and oil upgrading, the same kinds of wastes will arise in the revised mining and retorting scheme and their disposal will be handled as proposed in the DDP. See also Sections III.D.8. and III.E.9.

J. Fish and Wildlife Management Plan

The plans for fish and wildlife habitat management presented in the DDP appear suitable for the revised development scheme. These plans will be reevaluated, however, after the 2-year environmental baseline report is completed and will be reviewed periodically in light of the data obtained by the continuing monitoring program. Any changes made in these plans will be with the concurrence of the Area Oil Shale Supervisor.

K. Erosion Control and Surface Rehabilitation

Schemes for controlling erosion and rehabilitating the land surface are presented in the DDP in terms of surface erosion control, stream flow control, revegetation of disturbed areas, and vegetation of processed shale. Specific methods for achieving desired results are discussed in the DDP. Use of the different methods is contingent upon the results of their initial application and upon any policy changes that are made by regulating agencies. Thus, plans for erosion control and surface rehabilitation will be reviewed periodically and revised as necessary to accomplish the required results.

Revision of the mining and retorting plan for Tract C-b does not affect the general applicability of the erosion control and surface rehabilitation schemes presented in the DDP, and the plan in the DDP will be used.

It should be noted that disturbed surfaces on the tract have been revegetated and that raw shale is being vegetated successfully at OXY's D.A. Shale Project. Further experiments are planned to learn how to optimize vegetation of raw shale and revegetation of disturbed surfaces.

L. Oil and Hazardous Materials Spill Contingency Plan

The DDP contains a spill contingency plan that is appropriate and adequate for the above-ground activities in the revised mining and retorting scheme. Oil produced underground in the modified in situ process is confined in order for it to be recovered and piped to the surface. If any leaks should occur, the oil released will be gathered, together with the wet muck that covers the mine floor, to remove the fire hazard. This material will be handled as oily waste and disposed as described in Section V.I of the DDP. The environment will not be endangered by such occurrences.

M. Off-Tract Corridors

Access and utility corridors to the tract for the revised mining and retorting scheme are the same as proposed in the DDP. Other alternatives are being considered for the product oil pipeline, however.

New pipeline alternatives seem advised not because of a change in the mining and retorting scheme. Rather, the original proposal was related to a Colony pipeline which is unlikely to be built by the time it is needed for oil from Tract C-b. Also, revised market forecasts indicate that the north central states are likely to be more deficient in crude oil than the original Four Corners destination.

A principal alternative being considered goes generally north and east from the tract to an existing pipeline near Casper or Guernsey, Wyoming. This pipeline is reported to have capacity for an additional 70,000 to 80,000 bbl/day and runs east to the north central states.

The exact route for the alternative has not been selected. Its selection will necessarily take account of environmental factors. Appropriate environmental studies will be made, and required permits will be obtained before the pipeline is built.

N. Thermal Effects

Order-of-magnitude estimates have been made of the temperature at the surface above the in situ retorts. The calculations indicate that the surface temperature will be increased on the order of 0.1°F. This increment is less than ordinary variations from year to year. It will take many years for this increment to be realized, and it will decay after retorting is finished.

VI. ENVIRONMENTAL MONITORING PLANS

Plans to monitor the effects, if any, of the project on the flora, fauna, hydrology, and air quality of the immediate surroundings have been developed in support of the DDP and the lease suspension. These plans are general and can be applied to the revised development scheme. As stated in the DDP, the plans are subject to refinement, depending upon such factors as the final baseline report (due in the Spring of 1977), specific plant design, and monitoring results. Any changes from the existing monitoring program will be worked out with the Area Oil Shale Supervisor as the project progresses and information becomes available.

Special attention will be paid to monitoring key indicators on a regular basis and examining other variables less frequently. This will focus attention on a manageable list of variables and optimize the usefulness of information obtained.

Data will be gathered in such a way as to maximize the total utility to several disciplines. For example, precipitation will be gauged at sites of interest to biologists as well as hydrologists and meteorologists. Where appropriate, monitoring will be designed to detect differences between affected or treated areas and unaffected or control areas. Statistical tests of significant differences will be applied where practical.

The monitoring program for the revised mining and retorting scheme will necessarily include monitoring the quantity and quality of water that accumulates in spent in situ retorts. The water quality parameters that will be monitored routinely will be determined after examining a comprehensive series of tests on the first few retorts. In OXY's D.A. Shale Project, 68 water quality parameters were examined for over a year before the list was reduced to 31 items for routine monitoring. The initial list of 68 items is shown in Table VI-A. The table also shows the parameters currently being monitored routinely at the D.A. Shale Project site. The 68-item list was prepared for both surface and subsurface water analyses on the basis of all known and suspected ions and pollutants. The list will be revised for screening purposes on Tract C-b in light of ore data and water produced in the mine.

Water samples will be taken from the in situ retorts weekly, monthly, or seasonally, depending upon the rates at which water accumulates and compositions change. In the early stages, samples will be taken frequently to determine how fast these changes occur and to establish schedules for subsequent sampling.

Table VI-A - Water Quality Parameters

Pesticides (Chlorinated), μg/l
Color, Platinum Cobalt Scale
*Specific Conductance, μmhos
Turbidity, FTU
*pH
*Total Alkalinity, mg/l $CaCO_3$
*Bicarbonate, mg/l $CaCO_3$
Total Organic Carbon, mg/l
Suspended Solids, mg/l
*Soluble Solids, mg/l
Volatile Solids, mg/l
*Sulfate (SO_4), mg/l
Hardness, mg/l $CaCO_3$
*Chloride, mg/l
*Fluoride, mg/l
*Chemical Oxygen Demand, mg/l
Odor, ASTM OII
Fecal Coliform Bacteria, colonies/100 ml
*Phenol, mg/l
Phosphorus, mg/l
Sulfite (SO_3), mg/l
Bromide, mg/l
*Nitrogen-Kjeldahl, mg/l
Nitrogen, Ammonium, mg/l
*Nitrate, mg/l
*BOD_5, mg/l
*Oil and Grease, mg/l
Sulfide, mg/l
Nitrite, mg/l
Cyanide, mg/l
Surfactants, mg/l
*Silicon, mg/l
Lithium, mg/l
*Sodium, mg/l
*Potassium, mg/l
*Arsenic, mg/l
Selenium, mg/l
Mercury, mg/l
Cadmium, mg/l
Zinc, mg/l
*Iron, mg/l
*Magnesium, mg/l
*Calcium, mg/l
*Boron, mg/l
Thallium, mg/l
*Chromium, mg/l
*Vanadium, mg/l
Cobalt, mg/l
*Nickel, mg/l
Strontium, mg/l
*Copper, mg/l
Barium, mg/l
*Manganese, mg/l
Silver, mg/l
Zirconium, mg/l
Titanium, mg/l
Molybdenum, mg/l
Antimony, mg/l
Tin, mg/l
Gallium, mg/l
Lead, mg/l
Aluminum, mg/l
Beryllium, mg/l
Yttrium, mg/l
Scandium, mg/l
*α, pCurie/l
*β, pCurie/l
*Radium 226, pCurie/l

---

[*] Items marked are in the list of 31 parameters monitored routinely at OXY's D.A. Shale site. Carbonate (CO_3) is also being monitored.

VII. SOCIOECONOMIC CONSIDERATIONS

Socioeconomic impacts arising from C-b activities were projected in an adjunct to the original DDP on the basis of manpower schedules. The manpower schedule for the revised mining and retorting scheme (Figure I-C) can therefore be compared with the original schedule to assess whether the impacts for the revised scheme are greater, lesser, or about the same as those originally projected. The salient differences are outlined below.

Construction and operating manpower increases from less than 50 to nearly 400 in about 18 months in the original scheme and in about 25 months in the revised scheme. Thus, the revised scheme affords about 7 more months to develop adequate housing and other amenities for this level of manpower and their families.

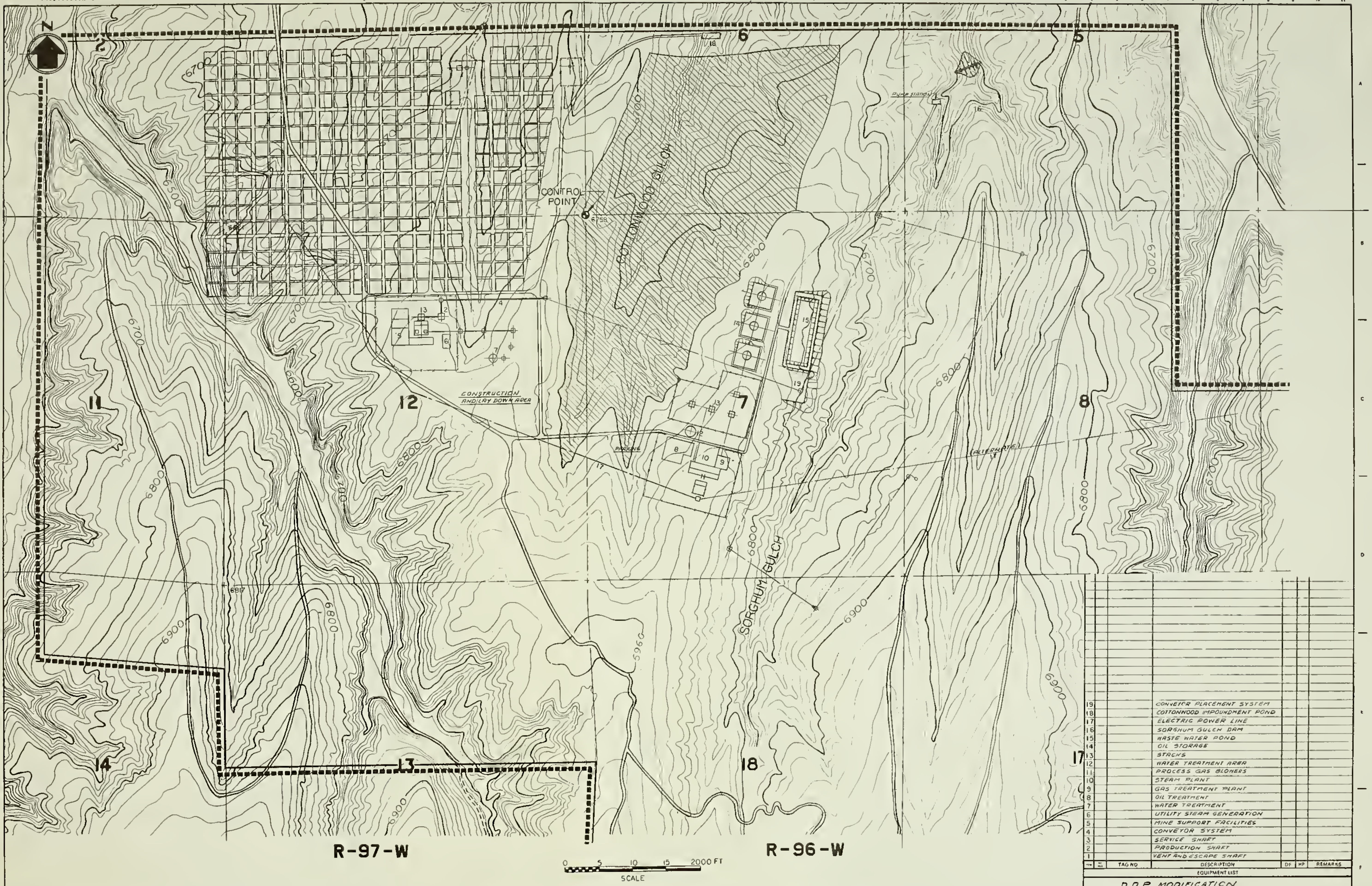
In the original scheme, the manpower level holds at 400 (or declines slightly) for about 15 months, then declines over a 3-month period to about 75 persons at the beginning of the fourth year of activity. In the revised scheme, the manpower level continues to grow during this period, reaching 1,180 at the beginning of the fourth year and then falling to 940 before beginning to grow again in the middle of the fourth year. Thus, the revised scheme is building a significant number of permanent jobs in the first 3 years while the original scheme offers mostly temporary employment during this time.

Also, the decline in the revised scheme from 1,180 to 940 is less than the decline in the original scheme during the same periods (240 vs 325). As a fraction of the peak value, the decline in the revised scheme is 20%, whereas it is 81% in the original scheme. Thus, both the absolute and relative impacts of the decline are less in the revised scheme than in the original scheme.

The peak in manpower in the revised scheme is related to plant construction. The temporary work force for this peak begins to grow at the middle of the fourth year, rises to 1,540 by the middle of the sixth year, and disbands by the beginning of the seventh year. The peak is superimposed on a permanent work force that is growing to 1,600 by the beginning of the seventh year. The maximum total employment during this time is 2,900, at the middle

of the sixth year, and consists of 1,540 temporary workers and 1,360 permanent workers. In the original scheme, the manpower peak begins in the sixth year, reaches about 3,100 in the middle of the eighth year, and then declines to about 1,100 permanent positions at the end of the ninth year. Thus, at least 2,000 of the positions in this peak are temporary. The revised scheme thus imposes fewer temporary workers on the community and provides more permanent employment than the original scheme.

The mitigating measures presented in the adjunct to the original DDP are appropriate for the revised scheme, particularly since peak employments in the two schemes are comparable, and since the numbers of temporary workers will be less and the initial manpower growth will come a little later in the revised scheme. The main manpower peak, however, comes earlier in the revised scheme than in the original DDP, and diligence will be required in preparing housing and other amenities for the influx.



		TAG NO	DESCRIPTION	DF	HP	REMARKS
19			CONVEYOR PLACEMENT SYSTEM			
18			COTTONWOOD IMPOUNDMENT POND			
17			ELECTRIC POWER LINE			
16			SORGHUM GULCH DAM			
15			WASTE WATER POND			
14			OIL STORAGE			
13			STACKS			
12			WATER TREATMENT AREA			
11			PROCESS GAS BLOWERS			
10			STEAM PLANT			
9			GAS TREATMENT PLANT			
8			OIL TREATMENT			
7			WATER TREATMENT			
6			UTILITY STEAM GENERATION			
5			MINE SUPPORT FACILITIES			
4			CONVEYOR SYSTEM			
3			SERVICE SHAFT			
2			PRODUCTION SHAFT			
1			VENT AND ESCAPE SHAFT			

EQUIPMENT LIST

D D P MODIFICATION
C-b SHALE OIL VENTURE
PROJECT PLOT PLAN

COMMERCIAL DEVELOPMENT
OVERALL PROGRAM

SCALE 1"=500.0'

FIG. I-A

DRAWN BY C. DT. 1-17-77
CHECKED BY
APP PROJ MGR 2/8/77

PARSONS-JURDEN
DIVISION OF
THE RALPH M. PARSONS COMPANY
100 West Walnut Pasadena, California 91124

Figure I-B - C-b Oil Shale Project
Commercial Development Schedule

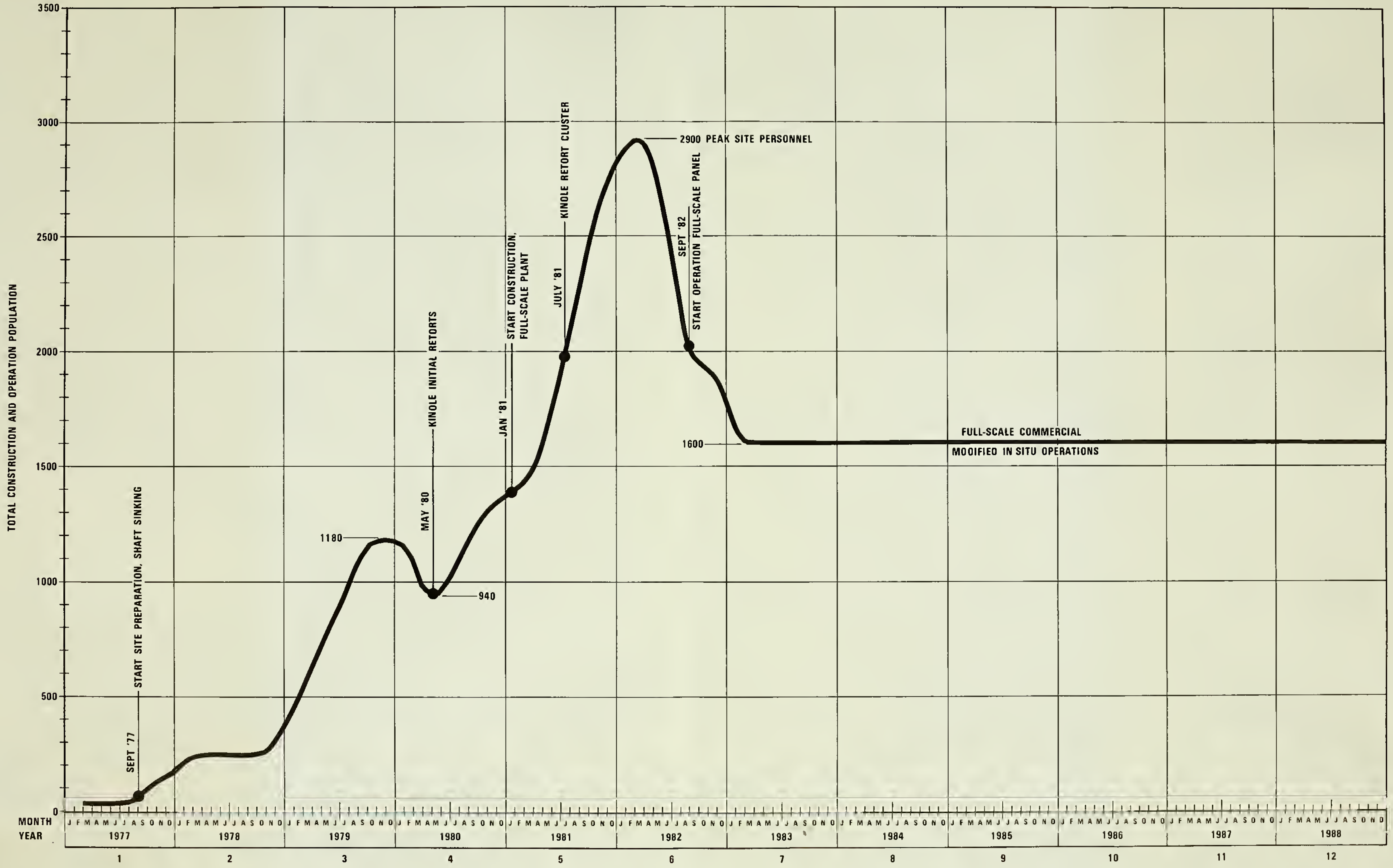


Figure I-C - Project Manpower Estimate

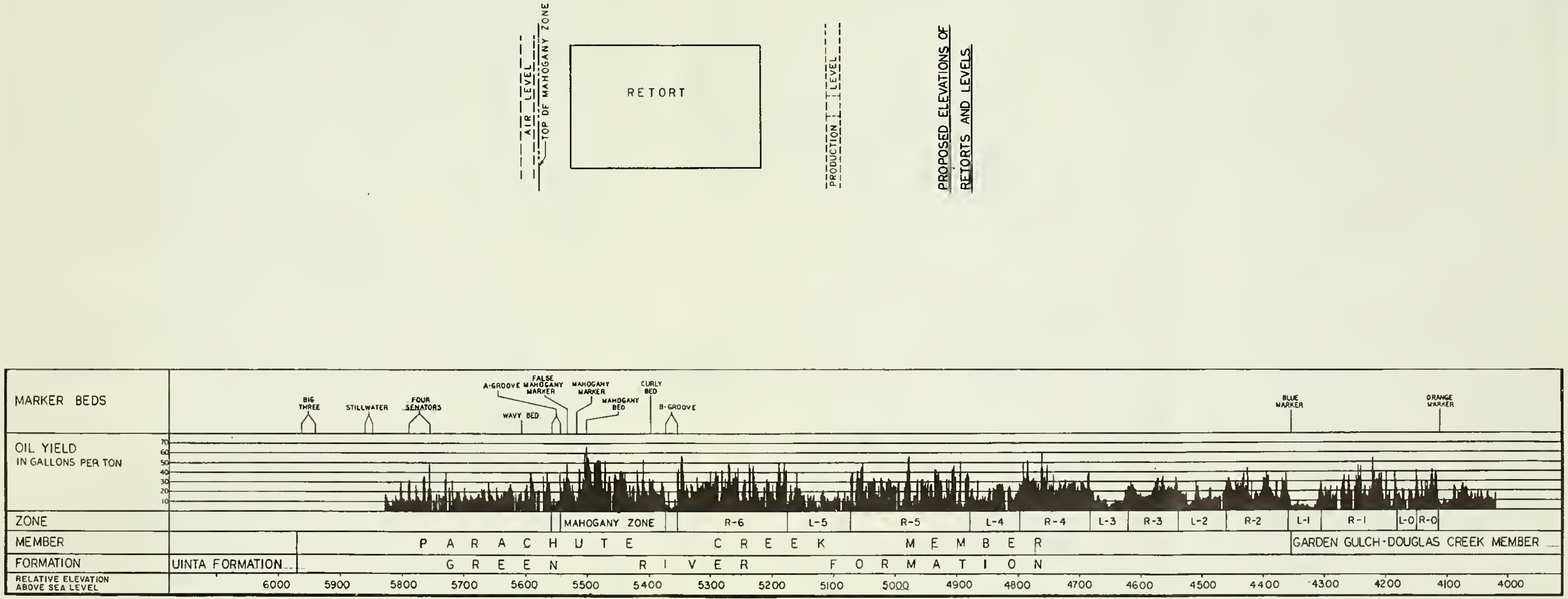
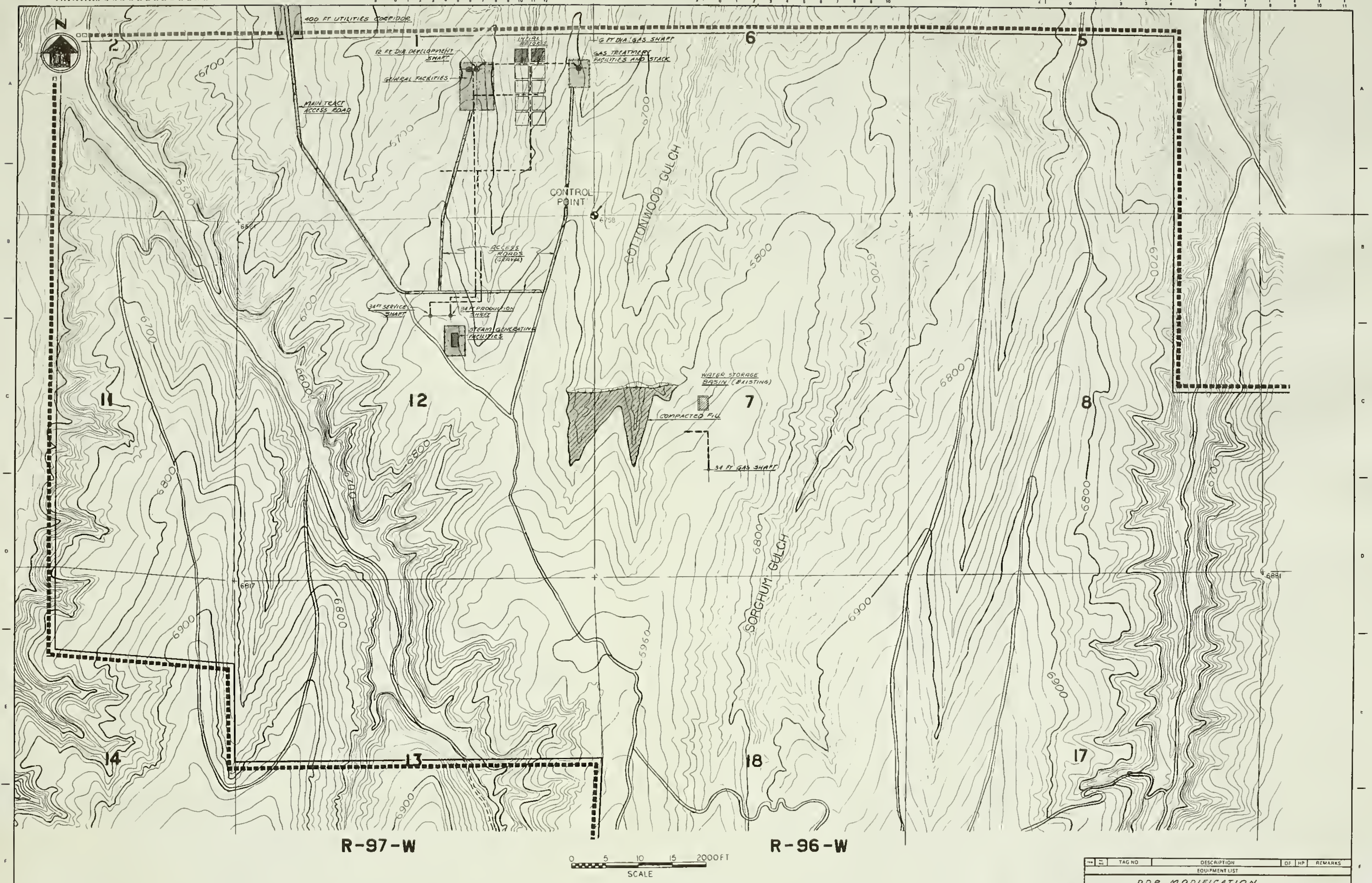


Figure I-D - Retort Elevation/Stratigraphic Section



TAG NO	DESCRIPTION	DF	HP	REMARKS

EQUIPMENT LIST

DDP MODIFICATION
C.b SHALE OIL VENTURE
PROJECT PLOT PLAN

COMMERCIAL DEVELOPMENT
ANCILLARY FACILITY
· INITIAL RETORTS

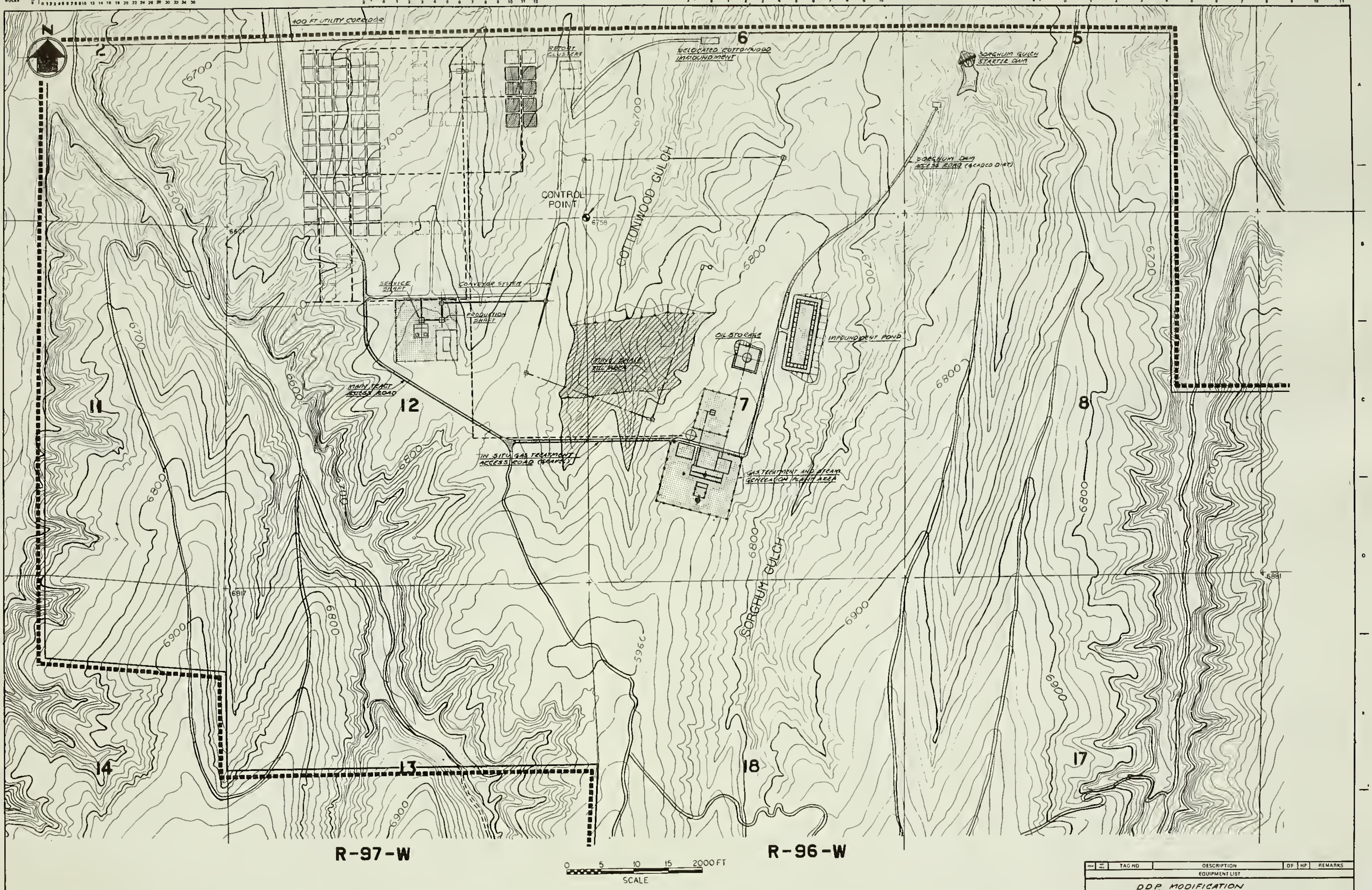
SCALE 1"=500.0'

FIG III-A

2-9-77

12-17-76
2/2/77

PARSONS-JURDEN
DIVISION OF
THE RALPH M. PARSONS COMPANY
100 West Walnut Pasadena, California 91124



		TAG NO	DESCRIPTION	DF	HP	REMARKS

EQUIPMENT LIST

DDP MODIFICATION
C-b SHALE OIL VENTURE
PROJECT PLOT PLAN

PRELIMINARY ISSUE
12-17-76
1/3/77

PARSONS-JURDEN
DIVISION OF
THE RALPH M. PARSONS COMPANY
100 West Walnut Pasadena, California 91124

COMMERCIAL DEVELOPMENT
ANCILLARY FACILITY
RETORT CLUSTERS

SCALE 1"=500.0'

FIG. III-B

1-9-77

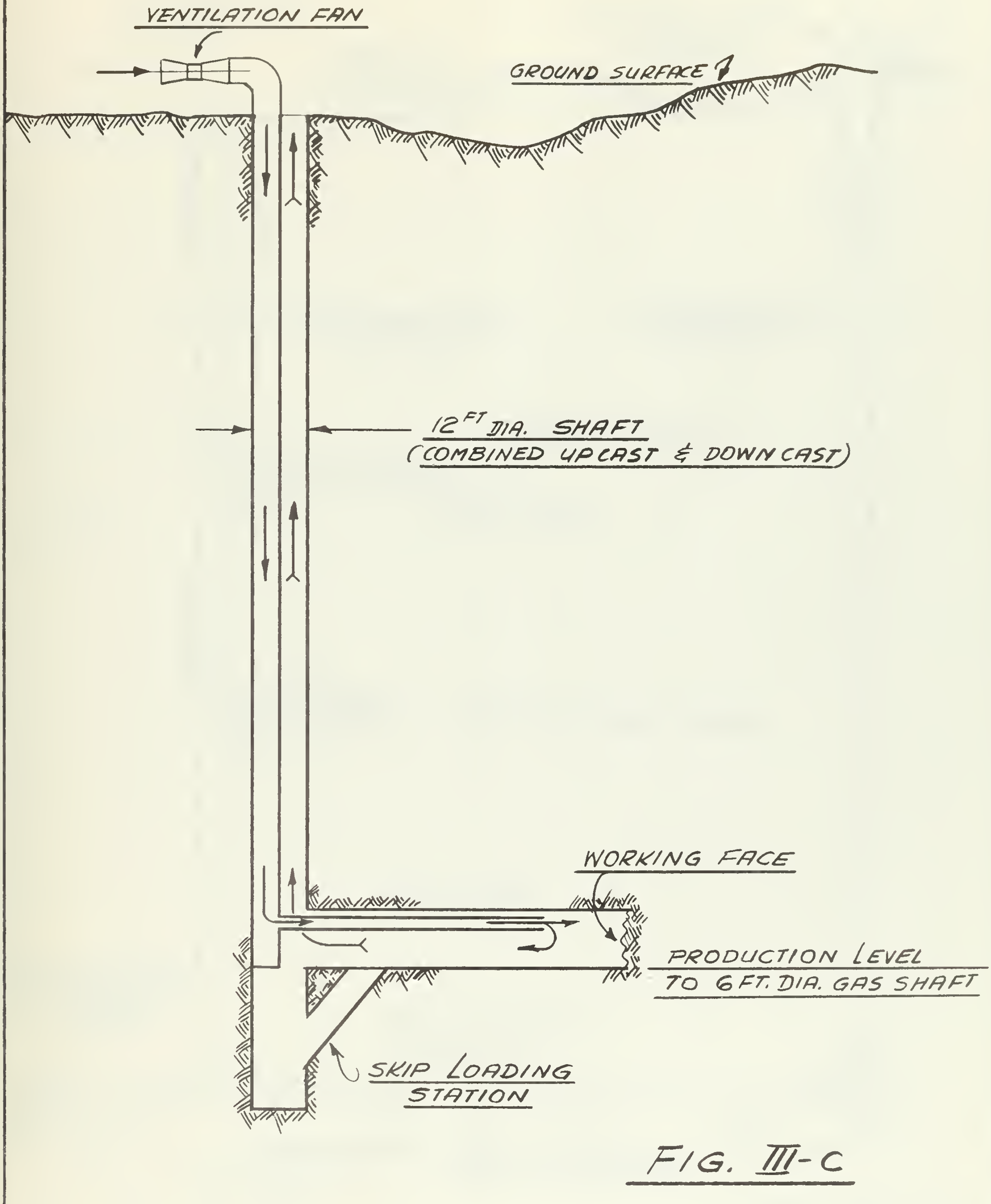

VENTILATION FAN
GROUND SURFACE
12 FT DIA. SHAFT (COMBINED UPCAST & DOWNCAST)
WORKING FACE
PRODUCTION LEVEL TO 6 FT. DIA. GAS SHAFT
SKIP LOADING STATION

FIG. III-C

DDP MODIFICATION, C-b SHALE OIL VENTURE
MINE VENTILATION CONCEPT SKETCH
INITIAL RETORTS STEP-1
(SHAFT & PRODUCTION LEVEL DEVELOPMENT)

2-8-77 BL/jm

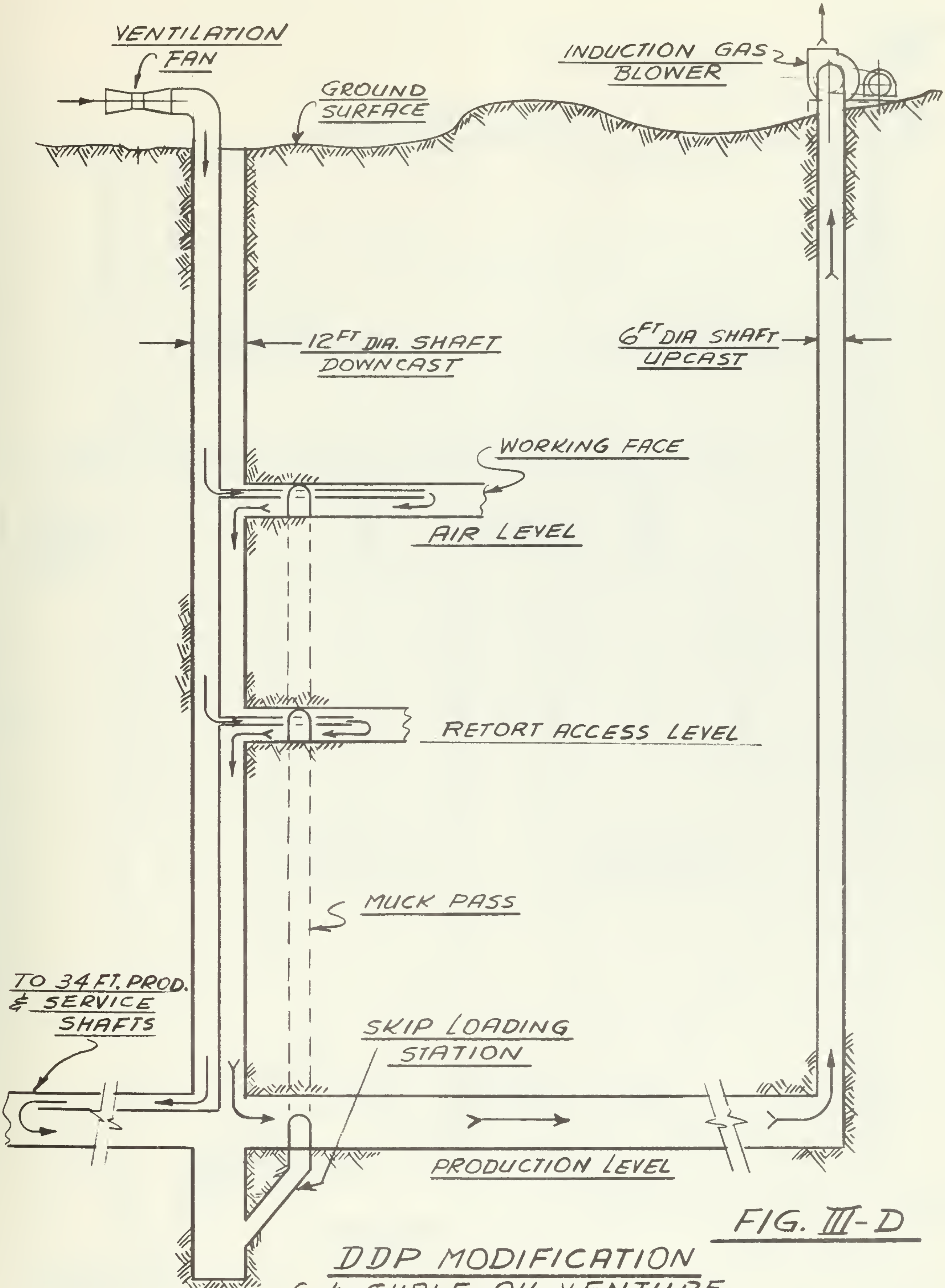


FIG. III-D

DDP MODIFICATION
C-b SHALE OIL VENTURE
MINE VENTILATION CONCEPT SKETCH
INITIAL RETORTS STEP -2
(RETORTS & AIR LEVEL DEVELOPMENT)

2-8-77 Bl/Jm

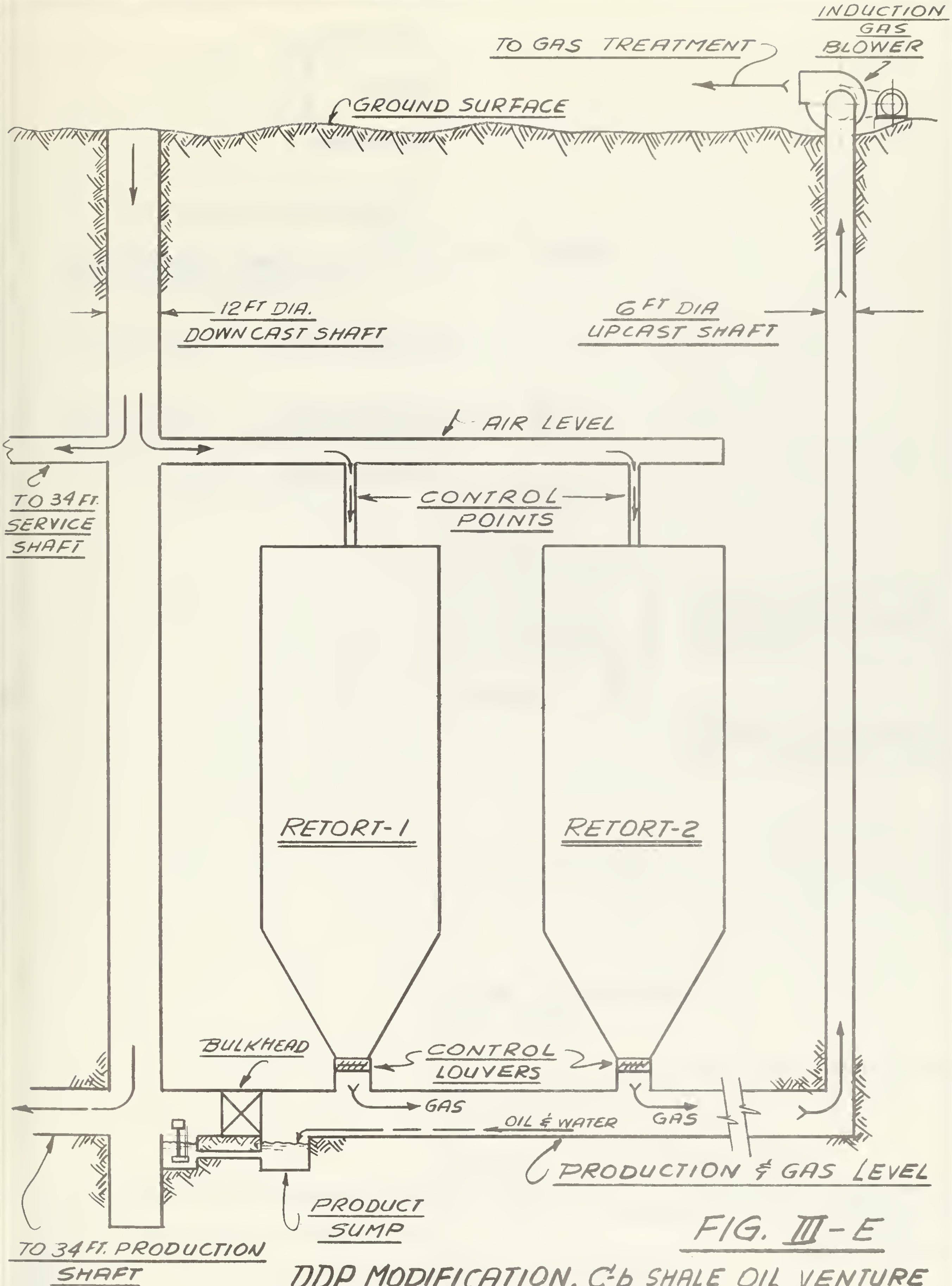


FIG. III-E

DDP MODIFICATION, C-b SHALE OIL VENTURE

MINE VENTILATION CONCEPT SKETCH

INITIAL RETORTS STEP-3

(INITIAL RETORTS OPERATION)

2-8-77 BL/jmn

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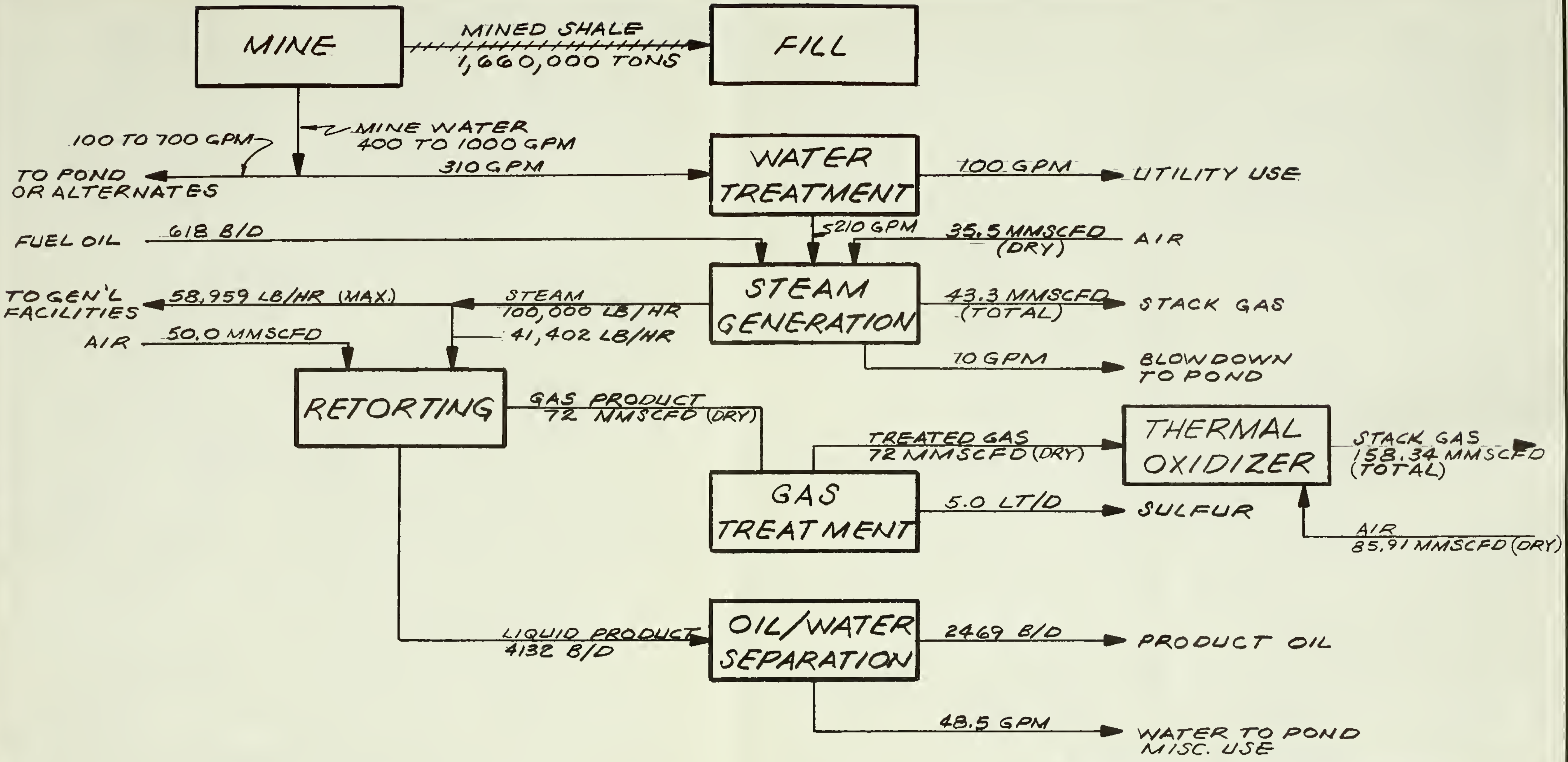

DDP MODIFICATION
C-b SHALE OIL PROJECT

REFERENCES	
DRAWING NO.	DESCRIPTION

REVISIONS

NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION
	2/8/77	HM					

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

TITLE BLOCK FLOW DIAGRAM
ANCILLARY FACILITY
INITIAL RETORTS

SCALE NONE

ACCOUNT NUMBER

JOB NUMBER 5628-02

DRAWING NUMBER FIG III-F

REV. 2/3/7

ENG-GE-21

DC-

DT-

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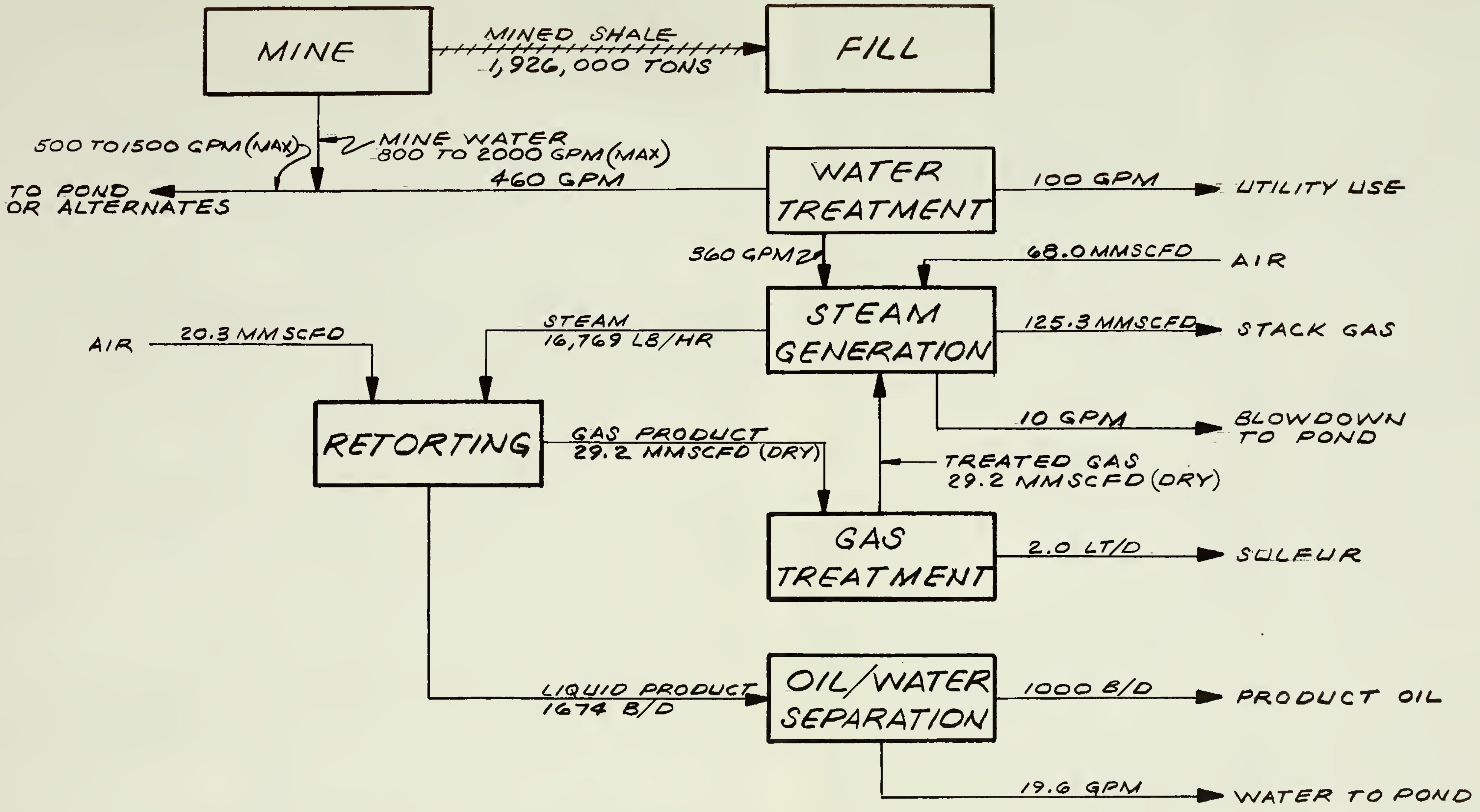


NOTE:

FLOWS ABOVE REPRESENT
FLOWS PER 1000 B/D

DDP MODIFICATION
C-b SHALE OIL PROJECT

REFERENCES	
DRAWING NO.	DESCRIPTION

REVISIONS							
NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION
	2/9/77	HM			NL		

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

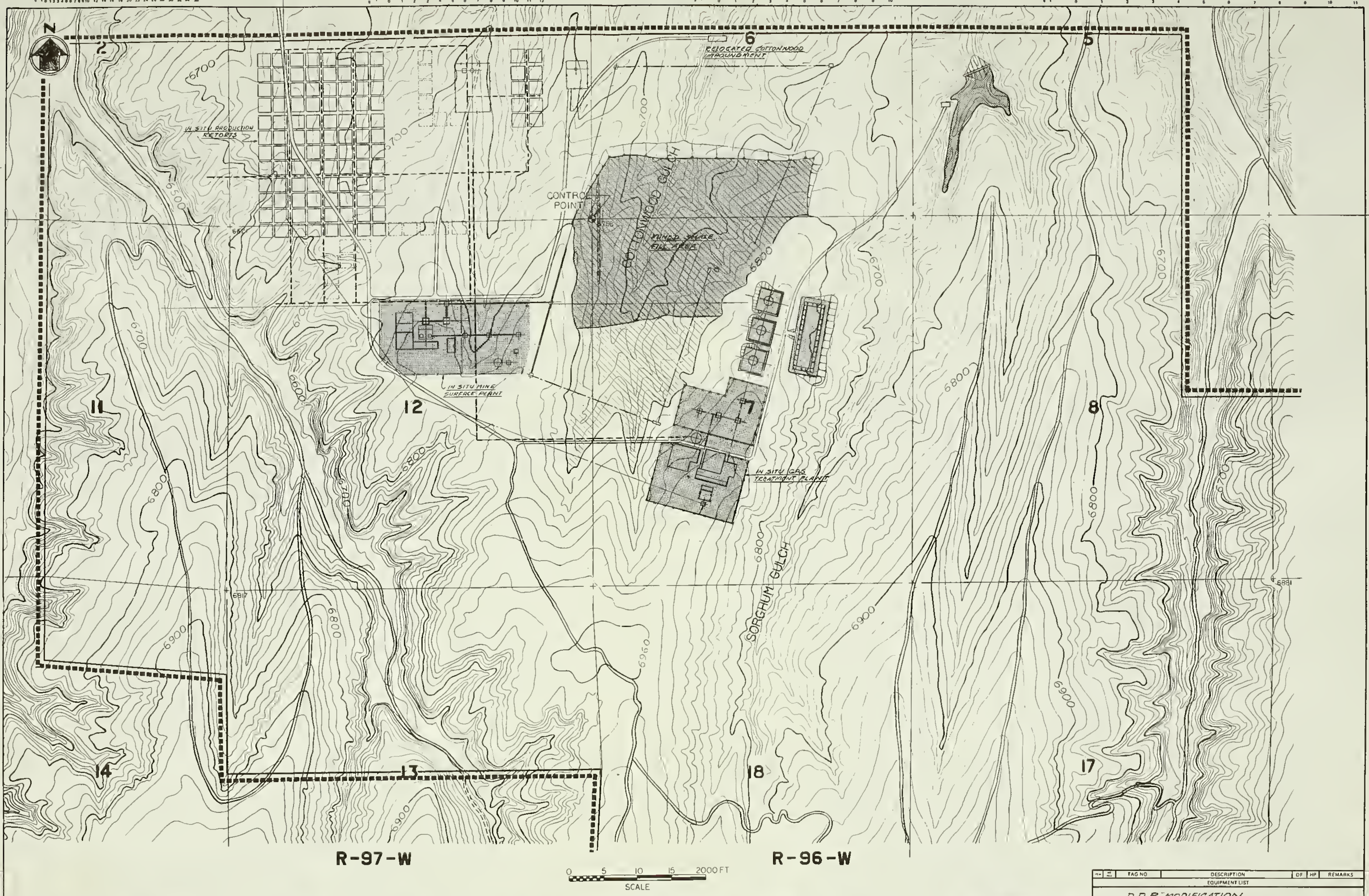
TITLE BLOCK FLOW DIAGRAM
ANCILLARY FACILITY
RETORT CLUSTERS

SCALE NONE
ACCOUNT NUMBER

JOB NUMBER 5628-02
DRAWING NUMBER FIG III-G
REV. 2/9/77

ENG-GE-21

DC-
DT-



		TAG NO	DESCRIPTION	DF	HP	REMARKS

EQUIPMENT LIST

D D P MODIFICATION
C-b SHALE OIL VENTURE
PROJECT PLOT PLAN

COMMERCIAL DEVELOPMENT
FULL SCALE
MODIFIED IN SITU PLANT

SCALE 1"=500.0'

FIG. III - H

DRAWN BY C. OF 2.17.76
CHECKED BY
APP DEPT HD
APP PROJ MGR 2-8-77
APP CLIENT

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100 West Walnut Pasadena, California 91124

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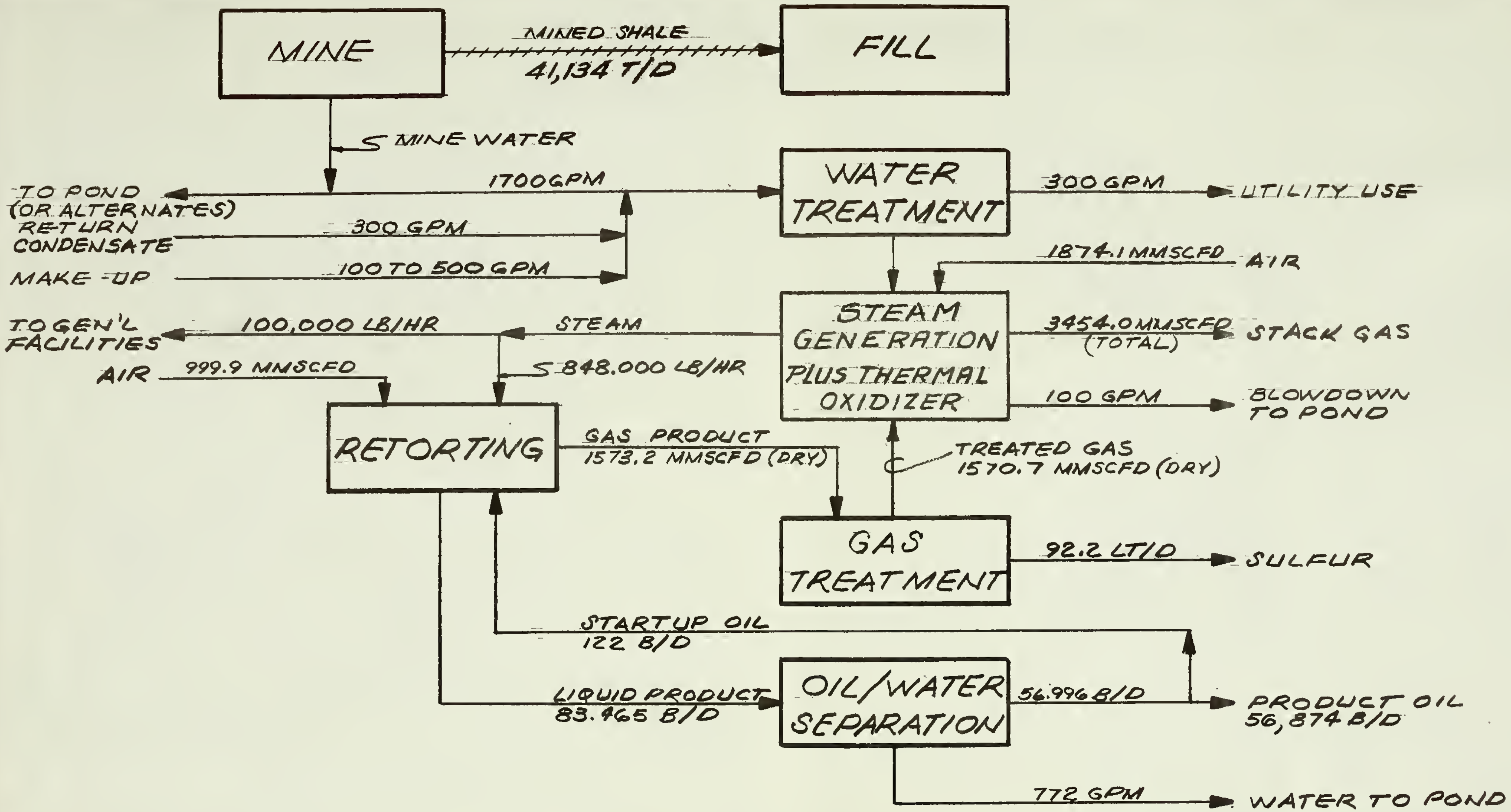

DDP MODIFICATION
C-6 SHALE OIL PROJECT

ENG-GE-21

REFERENCES

DRAWING NO.	DESCRIPTION

REVISIONS

NO.	DATE	BY	CK.	SEC.	PROJ.	CLIENT	DESCRIPTION
	2/8/77	HM			CGL		

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

TITLE
BLOCK FLOW DIAGRAM
FULL SCALE
COMMERCIAL FACILITY

SCALE
NONE

ACCOUNT NUMBER

JOB NUMBER
5628-02

DRAWING NUMBER
FIG. III - J

REV.
2/9/77

DC-

DT-

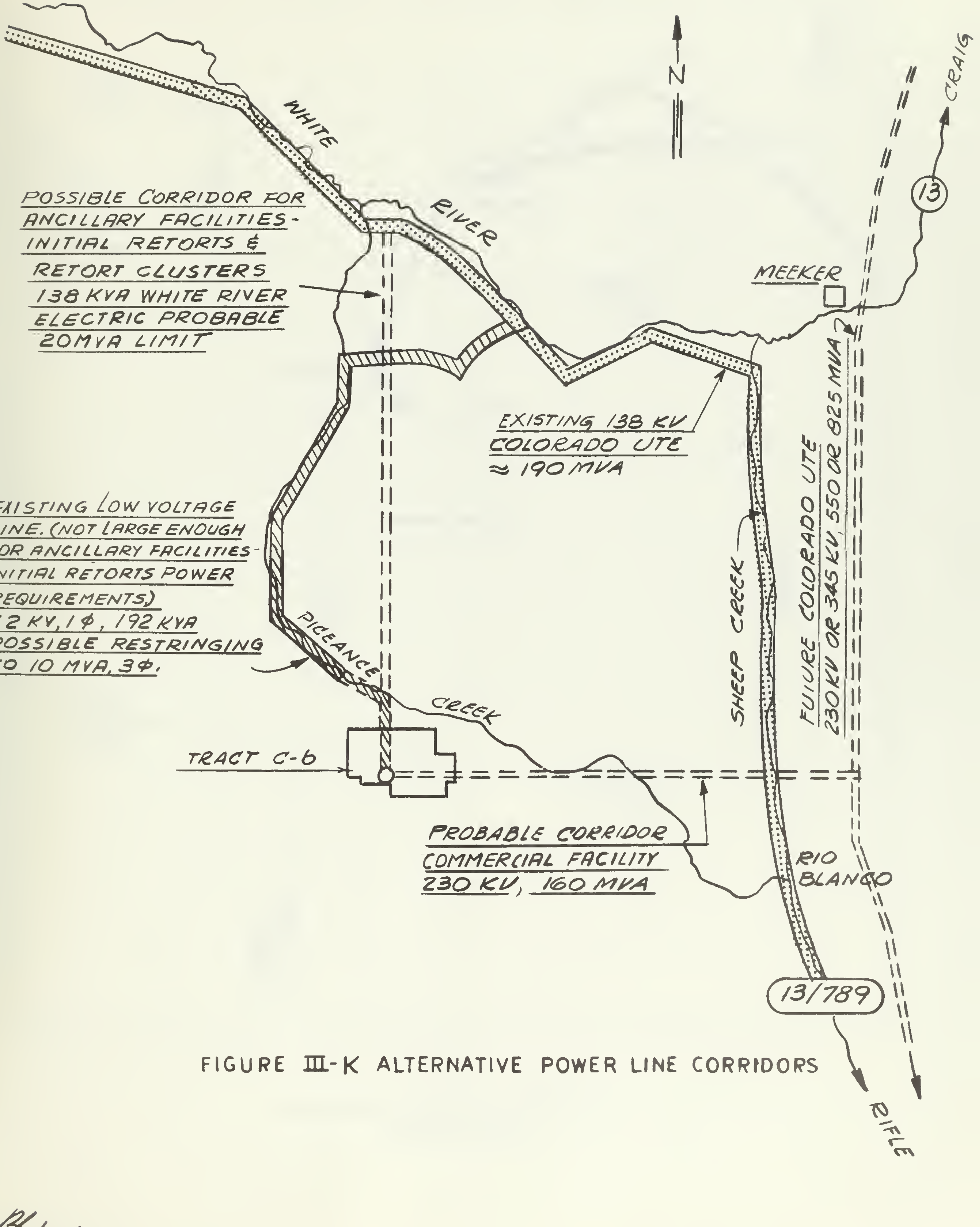
N
WHITE
RIVER
CRAIG
13
POSSIBLE CORRIDOR FOR ANCILLARY FACILITIES - INITIAL RETORTS & RETORT CLUSTERS 138 KVA WHITE RIVER ELECTRIC PROBABLE 20MVA LIMIT
MEEKER
EXISTING 138 KV COLORADO UTE ≈ 190 MVA
FUTURE COLORADO UTE 230 KV OR 345 KV, 550 OR 825 MVA
EXISTING LOW VOLTAGE LINE. (NOT LARGE ENOUGH FOR ANCILLARY FACILITIES - INITIAL RETORTS POWER REQUIREMENTS.) 7.2 KV, 1 Φ, 192 KVA POSSIBLE RESTRINGING TO 10 MVA, 3Φ.
SHEEP CREEK
PICEANCE
CREEK
TRACT C-b
PROBABLE CORRIDOR COMMERCIAL FACILITY 230 KV, 160 MVA
RIO BLANCO
13/789
RIFLE

FIGURE III-K ALTERNATIVE POWER LINE CORRIDORS

8·77 BK/coz

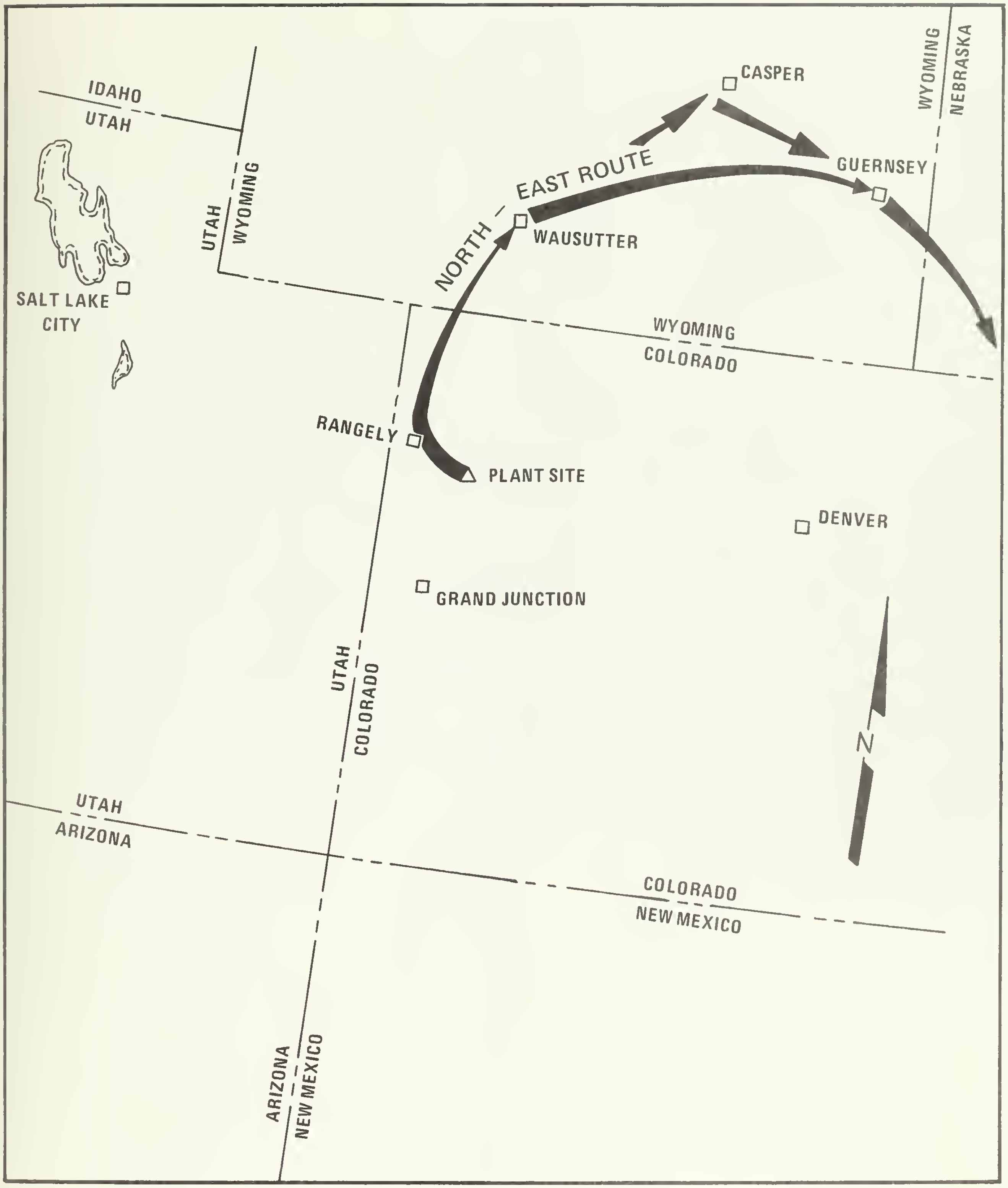

Figure III-L Crude Shale Oil Movement
Alternate Route

Form 1279–3
(June 1984)

BORROWE

TN 859 .C64 C3751 19

Oil shale tract C-b

DATE LOANED	BORROWER

USDI – BLM